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Coal quality and rank variation within Upper Cretaceous and Tertiary sediments, Alberta plains region

J.R. Nurkowski

ALBERTA RESEARCH COUNCIL
Natural Resources Division
Alberta Geological Survey

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Cover:
The Ardley coal zone exposed in the highwall of Pit 02 of the Highvale mine near Lake Wabamun.

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Abstract

Near-surface coals in the Alberta plains occur in Upper Cretaceous and Tertiary sediments of the Belly River Group, Horseshoe Canyon, Wapiti and Paskapoo Formations. These coal-bearing units contain significant coal resources of varying quality and rank. Statistical techniques were used to document both the distribution of, and the interrelationships between, the components of proximate and ultimate analysis and calorific value determinations.

The coals range in rank from subbituminous C to high volatile bituminous C. They have variable ash content and low sulfur content. The relationships between calorific value (dry basis, kJ/kg) and ash (dry basis, percent), and calorific value (moist mineral matter free, kJ/kg) and equilibrium moisture (MEQ, percent) were determined to be

$$CV(D) = 29262 - 286(Ash[D])$$

and

$$CV(MMMF) = 31816 - 442\ (MEQ).$$

Near-surface coals in the Alberta plains increase in rank toward the west-southwest (that is, towards the foothills/mountains region). A new model to explain this coal rank distribution is proposed. This model relates a coal seam's rank to its maximum (paleo-) depth of burial. This maximum depth was reconstructed on the basis of established relationships between equilibrium moisture loss and depth of coal seam burial. A least squares regression analysis of calorific value (MMMF, kJ/kg) on the calculated depth of burial (DOB, m) yielded the equation

$$CV(MMMF) = 14748 + 6.25(DOB).$$

This equation indicates a coalification gradient, determined on the reconstructed overburden, of 6.25 kJ/kg per metre (0.82 Btu/lb/ft) of depth (or overburden).

Progressively greater amounts of overburden existed in a direction toward the mountains at the time of coalification. Erosion since middle Tertiary time has removed between 900 and 1900 m (3000 and 6200 ft) of sediment; the greatest amount of removal is in the west southwest area, where coals of higher ranks are exposed.

Introduction

Background

In the course of its ongoing investigation of the coal resources in the Alberta plains, the Geological Survey Department of the Alberta Research Council has accumulated a large number of proximate and ultimate analyses of coal samples. Between 1974 and 1980, 685 coal samples were analyzed (appendix 1). The purpose of this bulletin is two-fold. The first purpose is to describe and summarize the distribution of the components of a proximate and ultimate analysis for each coal-bearing unit, using the recently acquired data. The last comprehensive attempt at this was made by Stansfield and Lang (1944) and Campbell (1964), who used samples collected from mines in the plains area. In addition to describing the distributions of individual components, this bulletin also documents component interrelationships. The second purpose of the bulletin is to develop a better understanding of the geological factors which control the distribution of coal ranks within the plains region.

Regional geology

The coal-bearing portion of Alberta can be divided into two geographic regions: the folded and faulted foothills and mountain region, and the flat-lying to gently dipping plains region (figure 1). Coals of significant thickness are known to occur in both areas in Cretaceous and Tertiary rocks (Williams and Murphy, 1981; Yurko, 1975; Stansfield and Lang, 1944).

Four prolific coal-bearing horizons are present within Upper Cretaceous and Tertiary sediments in the plains of Alberta: Foremost and Oldman Formations of the Belly River Group, Horseshoe Canyon Formation, Wapiti Formation and Scollard Member of the Paskapoo Formation (figure 2). The outcrop extent of each of these units is shown in figure 1. The coal-bearing strata dip regionally to the west southwest (Energy Resources Conservation Board, 1983), from near horizontal in the eastern portion of the plains area to over 8.6 m per km in areas near the foothills.

The stratigraphic terminology of Irish (1970) is followed for the Scollard Member and of Williams and Burk (1964) for the Belly River Group,[1] Foremost, Oldman, and Wapiti Formations. In this study the term "Horseshoe Canyon Formation" encompasses the Horseshoe Canyon Formation as well as the Whitemud Formation of Gibson (1977) and Irish (1970). Use of this new definition of the Horseshoe Canyon Formation can be found in Nurkowski (1980) and Nurkowski and Rahmani (in press).

The Belly River Group (figure 2) consists dominantly of sandstones with associated coals, siltstones and shales. Deposition of the sediments occurred in continental, marine and marginal marine environments (Williams and Burk, 1964). Individual coal seams attain thicknesses up to 3 m (10 ft); cumulative coal thicknesses for the entire group range up to 6 m (20 ft; Holter and Chu, 1978).

The Bearpaw Formation (figure 2) is shale-dominated and contains minor amounts of sandstone. It was deposited under marine and marginal marine conditions (Williams and Burk, 1964). Thin coal seams of considerable lateral continuity are present in the upper part of the formation.

The Horseshoe Canyon Formation (figure 2) is sandstone dominated, with coals, siltstones and shales. Sediment deposition probably occurred in both continental and marginal marine environments (Rahmani, 1981; Nurkowski and Rahmani, in press). Coal seams up to 5 m (16 ft) thick occur in this formation, with areas of cumulative coal thicknesses up to 12 m (39 ft) (Holter *et al.*, 1976).

The Wapiti Formation (figure 2) occurs in the north-central portion of the province (figure 1) and is

[1]also known as the Judith River Formation.

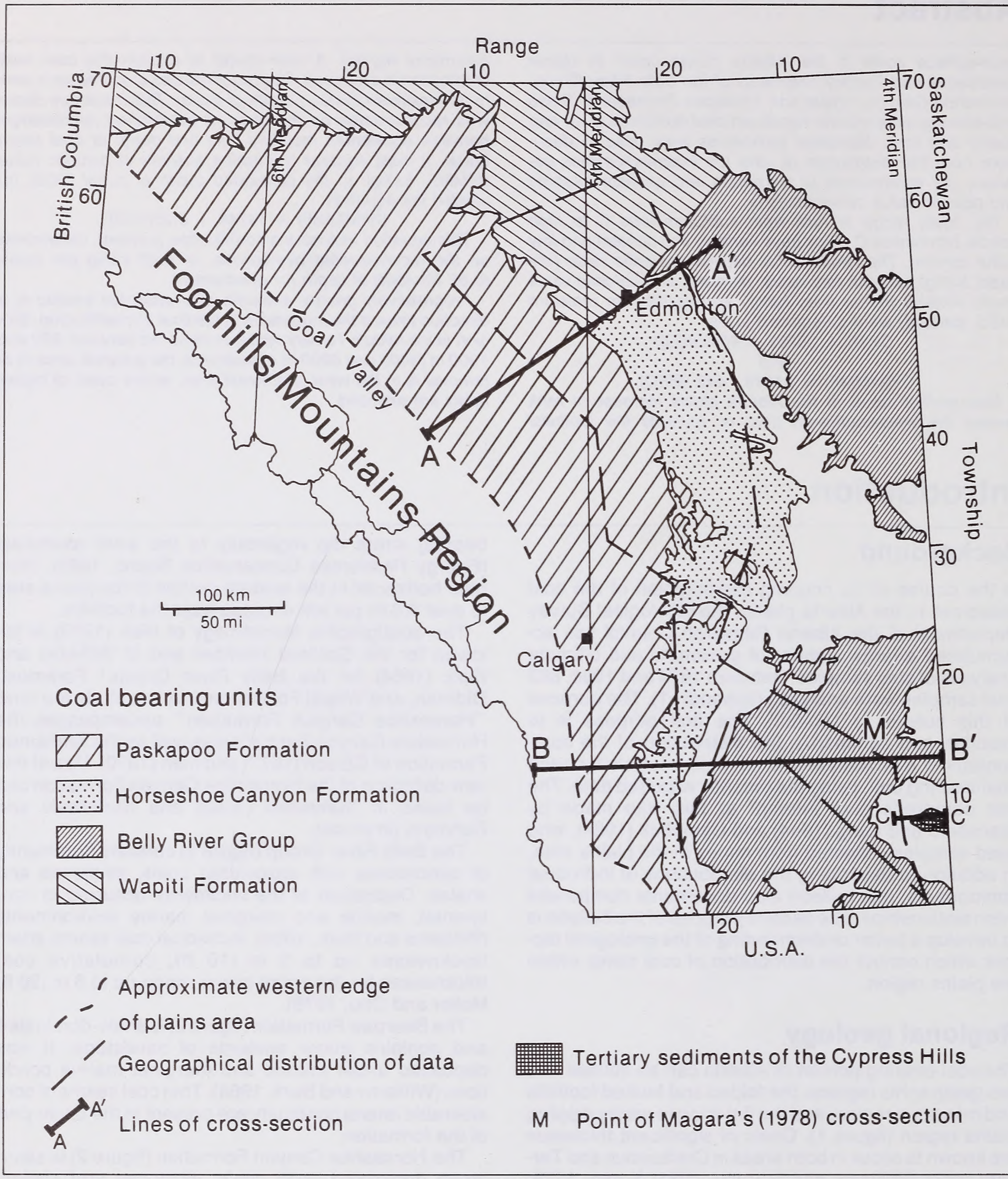

Figure 1. Outcrop distribution of Upper Cretaceous and Tertiary coal-bearing units of the plains region (from the Geological map of Alberta, Alberta Research Council 1972)

equivalent to sediments of the Belly River Group and the Horseshoe Canyon Formation in areas where the Bearpaw Formation is absent. The Wapiti Formation is sandstone dominated, containing coals, siltstones and shales. Chu (1978) reports coal seams up to 3 m (10 ft) thick within this formation.

The Battle Formation (figure 2) is a distinct widespread shale unit (Binda, 1970) that is devoid of coal. This formation is very useful for separating the lithologically similar upper Horseshoe Canyon Forma-

tion from the lower Paskapoo Formation. It is readily recognizable in exposures by its medium to dark purplish-grey to lime-grey color (Gibson, 1977), and, in subsurface geophysical logs, by its very low resistivity and higher gamma ray readings. Because of its thinness (commonly 7 to 11 m [22 to 36 ft]; Nurkowski and Rahmani, in press), the formation was not plotted on the outcrop map (figure 1).

The Scollard Member of the Paskapoo Formation (figure 2), the uppermost of the major coal-bearing units, contains both the thickest and the most continuous coal seams. Carrigy (1971) interpreted the sediments as having formed entirely within a continental environment. The Scollard is defined as the generally finer-grained section of sediments overlying the Battle Formation and containing the thick coals traditionally named the "Ardley" coals. Coal seams up to 5 m (16 ft) thick, as well as coal zones with cumulative coal thicknesses up to 24 m (79 ft), occur in this member. Coal occurrences in Paskapoo Formation sediments other than in the Scollard Member are rare.

Sampling and analytical procedure

Between 1974 and 1980 the Alberta Research Council drilled 427 testholes in order to evaluate the near surface coal resources of the plains region. These testholes are concentrated in areas where the coal-bearing units crop out (figure 1) or occur at a shallow depth. In total, these drilling programs accumulated information on 89.6 km (294 000 ft) of drilled sediment and 2.1 km (6900 ft) of cored sediment. Cutting samples of coals were collected periodically when coal seams were encountered during conventional open hole drilling. These samples were washed, bagged and sent for analysis. Portions of coal seams collected from cores were also bagged and sent for analysis. Contamination of coal samples (especially cuttings) by coal seams higher in a drill hole was not considered a major problem because inspection of caliper logs from Alberta Research Council testholes indicates that shallow coals do not tend to cave or wash out.

In total, 685 proximate analyses, 621 calorific value determinations and 104 ultimate analyses were performed. Results of these analyses are tabulated in appendix 1.

A proximate analysis involves determination of moisture, ash, volatile matter and fixed carbon; each component is expressed as a percentage of the sample. Three moisture values are generally reported: an as-received moisture, which represents the moisture content of the coal sample as it was received in the laboratory; an as-determined moisture, which represents the moisture content at the time of the analysis; and an equilibrium or bed moisture, which is considered to represent the moisture content of the seam in situ. Berkowitz (1979, p. 31) describes equilibrium moisture: it is " the amount of water that a coal will hold when fully saturated at nearly 100 percent relative humidity (as in an undisturbed coal seam) and thus reflects the total pore volume of the coal accessible to moisture." Equilibrium moisture is determined following the procedure outlined in ASTM 1492, which requires that a sample of coal be brought to 97 to 98 percent relative humidity (at 30 $\pm$ 0.2°C), then weighed, dried, and weighed again to determine the amount of moisture loss.

The ash content, the inorganic residue remaining after coal combustion, is determined following the procedures outlined in ASTM 3174. A weighed sample of dried coal is combusted in excess air at a temperature of 725 ($\pm$25)°C and the residue is weighed to determine the ash content. In order to use the ASTM rank classification system of coal, one must distinguish between ash in coal and mineral matter in coal. The ASTM classification system requires that calorific value, volatile matter (VM) and fixed carbon (FC) be expressed on a mineral matter free (MMF) basis. During conventional ashing of coal, dehydration (for example, $FeSO_4.nH_2O$ to $FeSO_4$), decomposition (for example, $CaCO_3$ to CaO) and oxidation (for example, FeS to $FeSO_4$) occur, as well as partial loss of volatile constituents, particularly Hg, K, Na, Cl, P and S (Berkowitz, 1979, p. 49). The percent ash value obtained for the sample does not, therefore, reflect the true mineral matter content in the sample. Stansfield and Lang (1944) maintain that, on average, ten parts of mineral matter in coal leave only nine parts ash. The Parr Formulae (appendix 2) allow for translation of the analytical values to a MMF basis.

Volatile matter in coal, the portion of the sample that is driven off during heating, includes such substances as tars and other hydrocarbons, CO, CO_2 and CH_4. The content of volatile matter is determined following procedure ASTM 3175. A weighed sample of coal is heated in a covered crucible to 950 ($\pm$20)°C for 7 minutes, taking care to prevent oxidation of the sample. The remaining sample is weighed and the weight loss minus the weight of sample moisture determines the volatile matter constituent of the coal.

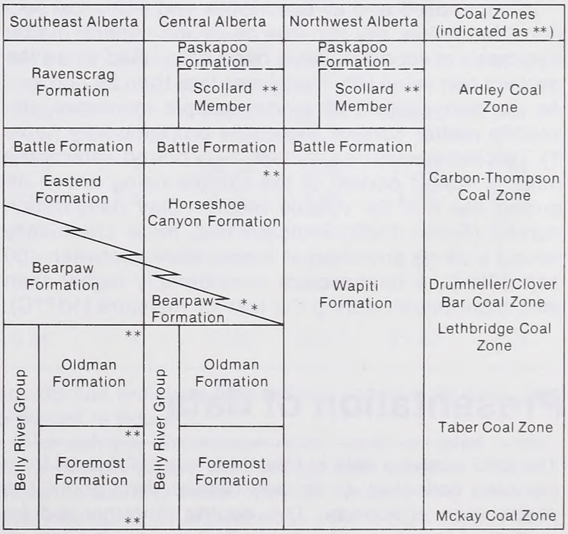

Figure 2. Stratigraphic nomenclature of the Upper Cretaceous and Tertiary in the southern and central plains area

The fixed carbon portion of the coal sample is determined essentially by difference, using the relationship % FC = 100 - (% moisture + % VM + % ash).

The components of a proximate analysis can be expressed or reported in a number of ways, depending on the moisture values used. When moisture data are available, the most common method of reporting proximate analyses is on an as-received, an as-determined, and a moist or equilibrium moisture basis. Samples can also be expressed on a dry or dry ash-free basis by removing the moisture or both moisture and ash; the remaining components are then calculated to total 100 percent. The method used to calculate moist, dry (D) and dry ash-free (DAF) basis is explained in appendix 3.

An ultimate analysis of ash-free coal describes its elemental composition and includes determination of carbon, hydrogen, nitrogen, sulfur and oxygen, each expressed as a percentage of the sample. The sulfur contents presented in this report include both the organic and inorganic forms of sulfur. The oxygen content is determined by difference, using the relationship

% oxygen = 100 - (% C + % H + % N + % S).

The oxygen and hydrogen contents reported in ultimate analyses do not include the oxygen and hydrogen of the sample moistures. Where available, these analyses are reported on a dry basis in appendix 1.

The calorific value of a coal sample is determined following the procedure outlined in ASTM 2015. This procedure requires that a weighed sample of coal be combusted in a calorimeter, with the calorific value of the coal sample being equated to the resulting rise in water temperature. Values reported in appendix 1 are expressed in kilojoules per kilogram of coal. (To translate these units to Btu/lb, multiply the kJ/kg value by a conversion factor of 0.43.) For comparison, calorific values can be calculated to both a dry and a dry ash-free basis following methods outlined in appendix 3.

In appendix 1 and all descriptive and statistical sections that follow, dry ash-free basis and mineral matter free basis of reporting have been calculated when the percent ash value (dry basis) was less than 25 percent. As the ash content of a coal sample increases, the volatile matter content increases proportionally (table 1). This increase is due to chemically bound water in the mineral matter portion of the sample being driven off during the test for volatile matter. Clay dehydration curves (Grim, 1953) indicate that most chemically bound water is driven off at temperatures between 400 and 600°C, a temperature considerably higher than that encountered during the test for moisture (107°C).

Table 1. Variation of the mean value of volatile matter content with respect to increasing ash content (all values in percent)

Ash (dry)	Volatile matter (dry ash-free)	Ash (dry)	Volatile matter (dry ash-free)
0 - 10	42.4	50 - 60	49.3
0 - 25	43.1	60 - 70	50.1
10 - 20	42.7	70 - 80	62.4
20 - 30	45.1	80 - 90	76.4
30 - 40	47.3	90 - 100	82.5
40 - 50	47.1		

The anomalous volatile matter contents in high ash samples are therefore in error, because these values contain both true volatile matter and moisture. For this reason an arbitrary ash cutoff of 25 percent was chosen; samples with less than 25 percent ash were calculated to a dry ash-free and mineral matter free basis.

The coal samples collected in 1974 and between 1976 and 1980 were analysed by Chemical and Geological Laboratories, Edmonton, and those taken in 1975, by Cyclone Engineering, Edmonton. A number of samples were also analysed by the Alberta Research Council. No attempt was made to check the repeatability or accuracy of the analytical results from the various labs.

In order to determine the coal-bearing formation from which each of the coal samples was collected, previously published Alberta Research Council reports were searched and coal seam correlations made in those reports were noted. In general, those testholes drilled during 1974 evaluated the Scollard Member, those during 1975 the Horseshoe Canyon Formation those during 1976 the Belly River Group, those during 1977 the Wapiti Formation, and during 1978, 1979 and 1980 the Horseshoe Canyon Formation.

In 1980 and 1981 the results of the 685 coal analyses (appendix 1) were placed in the Alberta Research Council's Digital Vax 11/780 computer. A computer data base management system known as DATATRIEVE was used to retrieve data selectively and recalculate them to consistent bases. In order to compute component interrelationships and descriptive statistics on analytically determined components, output from DATATRIEVE was transferred to the University of Alberta's Amdahl 470V/8 computer. The MIDAS statistics package was then used to generate the information contained in the tables, histograms and cross-plots that follow.

Presentation of data

The coal analysis data in this study were obtained from samples collected at various depths throughout the plains area of Alberta. The depths, summarized for each coal-bearing unit in table 2, represent the top, or shallowest depth of the sampling interval. As will be seen, quality characteristics of coals are related to both depth and geographic location of the sample.

Proximate analysis

The descriptive statistics calculated for each component of a proximate analysis include the minimum, max-

Table 2. Summary of component distributions

	Scollard Member					Horseshoe Canyon Formation				
	n	Min	Max	Mean	S.D.	n	Min	Max	Mean	S.D.
Depth, m	227	20	275	168	-	365	18	319	114	-
Equilibrium moisture, %	72	9.9	19.8	14.4	1.6	160	12.3	24.7	19.8	2.5
Ash (D), %	128	5.2	24.9	15.8	4.9	203	3.3	24.9	13.9	6.1
Volatile matter (DAF), %	124	34.1	58.3	40.6	3.7	197	34.6	65.4	44.0	3.6
Fixed carbon (DAF), %	124	41.6	65.8	59.3	3.7	197	34.5	65.3	55.9	3.6
Calorific value (MMMF), kJ/kg	72	22653	27538	25479	796	155	20204	27130	23048	1245
Calorific value (DAF), kJ/kg	128	28084	31599	29926	636	197	27433	32769	29315	868
Carbon (DAF), %	37	67.10	78.70	75.63	1.89	53	65.73	83.98	74.49	2.23
Hydrogen (DAF), %	37	3.20	6.34	4.63	0.48	53	4.28	5.94	5.05	0.30
Nitrogen (DAF), %	26	0.89	1.62	1.16	0.15	39	0.88	1.89	1.49	0.22
Sulfur (D), % (95% confidence level)	199	0.15	1.79 (0.36-0.41)	0.39	-	358	0.03	2.80 (0.44-0.50)	0.47	-
Oxygen (DAF), %	26	15.87	23.79	18.17	1.53	39	14.93	26.17	18.32	1.86

	Belly River Group					Wapiti Formation				
	n	Min	Max	Mean	S.D.	n	Min	Max	Mean	S.D.
Depth, m	41	51	250	146	-	49	15	217	102	-
Equilibrium moisture, %	16	8.5	26.9	14.0	6.3	0	n/a	n/a	n/a	n/a
Ash (D), %	32	6.9	24.7	16.6	5.9	47	4.5	24.6	11.5	4.5
Volatile matter (DAF), %	32	39.6	48.4	44.6	2.3	47	39.9	49.2	44.2	2.3
Fixed carbon (DAF), %	32	51.5	60.7	55.3	2.3	47	50.7	60.0	55.7	2.3
Calorific value (MMMF), kJ/kg	16	20104	29356	26065	2974	n/a	n/a	n/a	n/a	n/a
Calorific value (DAF), kJ/kg	32	26465	32094	29226	1749	47	26349	32394	28345	849
Carbon (DAF), %	10	71.77	76.47	74.72	1.52	4	68.26	73.82	71.87	2.61
Hydrogen (DAF), %	10	4.44	5.75	5.08	0.51	4	4.61	4.96	4.83	0.15
Nitrogen (DAF), %	4	1.32	1.94	1.89	0.06	4	1.34	1.61	1.48	0.11
Sulfur (D), % (95% confidence level)	41	0.33	1.19 (0.60-0.72)	0.66	-	59	0.11	0.95 (0.29-0.35)	0.32	-
Oxygen (DAF), %	4	14.41	16.29	15.57	0.84	4	19.53	25.44	21.50	2.78

imum and mean value and the standard deviation. These calculations were limited to samples containing less than 25 percent ash (D).

The moisture value considered to be of most importance in a coal sample is the equilibrium moisture, since it is taken to represent the in situ moisture of the coal and is required when determining the ASTM rank (table 3). The descriptive statistics of equilibrium moisture content are presented in table 2; the histograms of equilibrium moisture distribution, showing all data, are provided in figure 3.

The ash (D) distribution of the coal samples varies considerably (figure 4); the high ash samples (that is, those containing more than 25 percent ash) are probably samples of argillaceous coals, partings, or carbonaceous shales. Table 2 gives the descriptive statistics for ash content.

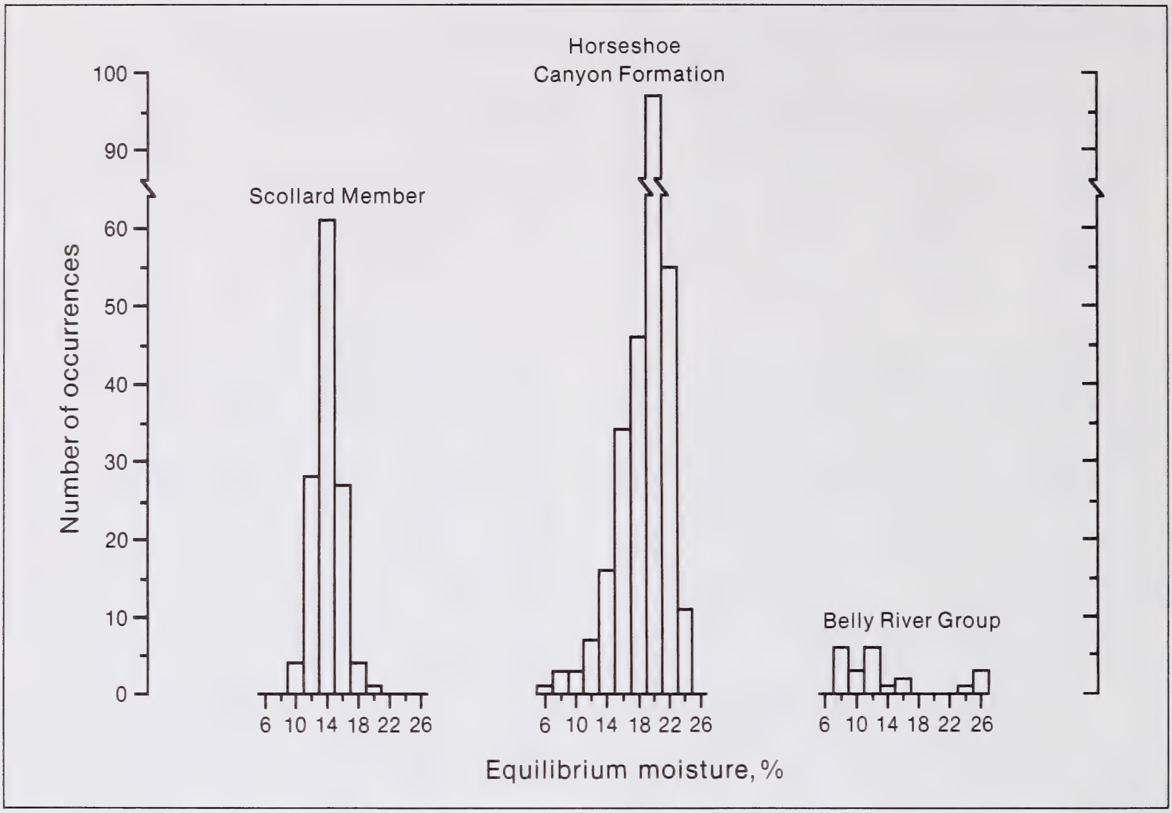

Figure 3. Distribution of equilibrium moisture percentages

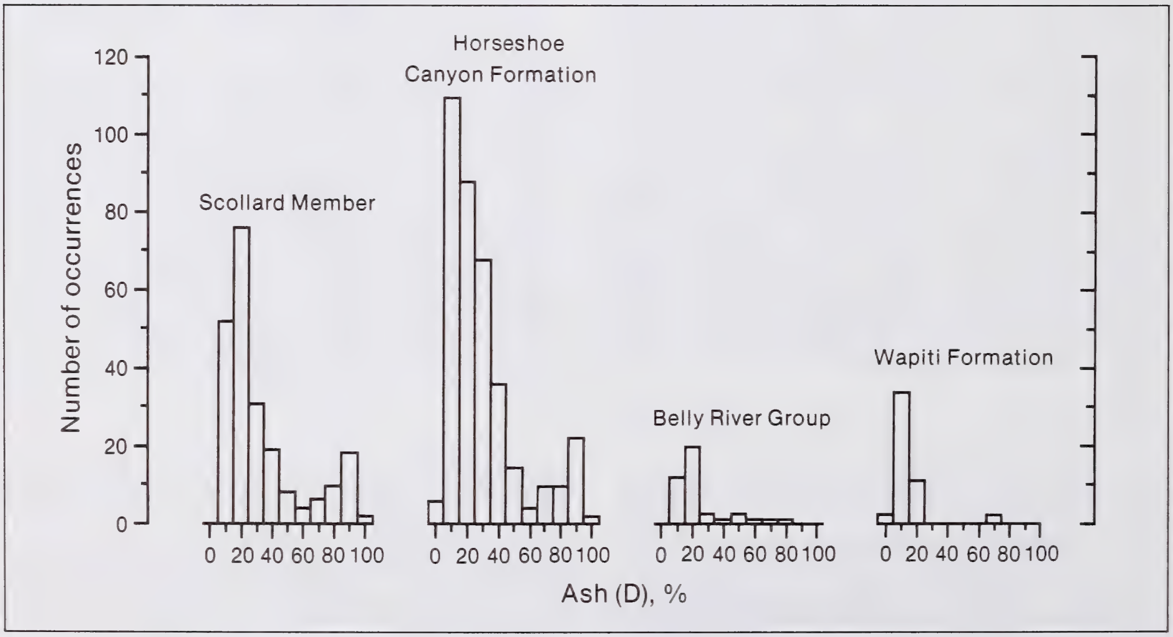

Figure 4. Distribution of ash (dry basis) percentages

Because of the variation of moisture and ash contents in the coal samples, both volatile matter and fixed carbon contents should be described and compared on a dry ash-free basis. Using this basis of reporting, the volatile matter and fixed carbon contents total 100 percent; the descriptive statistics for these components (table 2) are, therefore, related. The distribution of volatile matter is presented in figure 5.

Calorific value

If the ASTM classification of low rank coals (table 3) is to be used, calorific values must be expressed on a moist mineral matter free basis. Descriptive statistics for these calorific values, as well as for calorific values expressed on a dry ash-free basis, are presented in table 2. The distributions of calorific values, expressed to the above mentioned bases, are provided in figures 6 and 7. In these histograms, only coal samples containing less than 25 percent ash were considered. Table 2 shows that the coals range in rank from subbituminous C to high volatile bituminous C.

Ultimate analysis

A determination for carbon, hydrogen, nitrogen and oxygen (by difference) has been undertaken for only a minority of the samples; the descriptive statistics for these samples are presented in table 2. Because of the association of burning high sulfur coals with environmental pollution, however, a considerable number of samples were analyzed for sulfur content.

The sulfur (D) distributions for the Scollard Member, Horseshoe Canyon Formation and the Wapiti Forma-

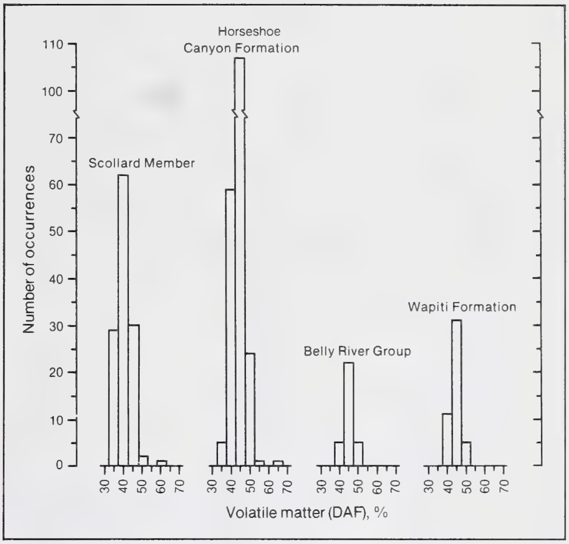

Figure 5. Distribution of volatile matter (dry ash-free basis) percentages

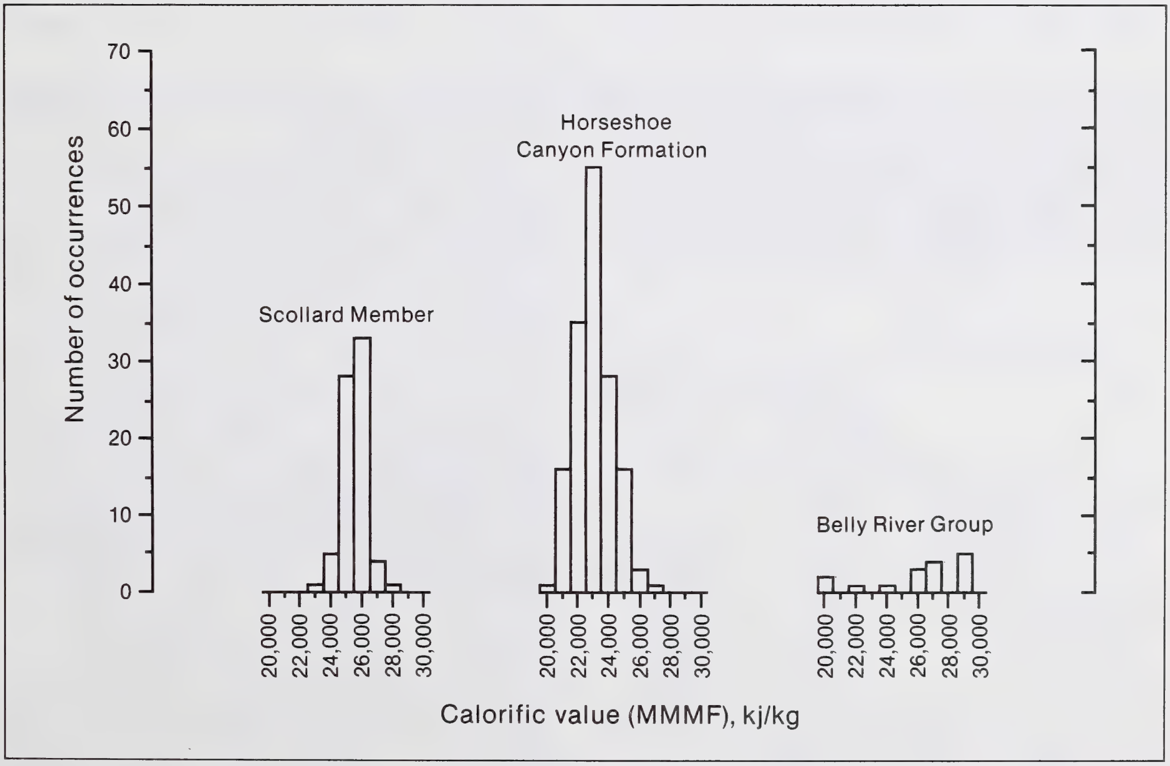

Figure 6. Distribution of calorific values (moist mineral matter free basis)

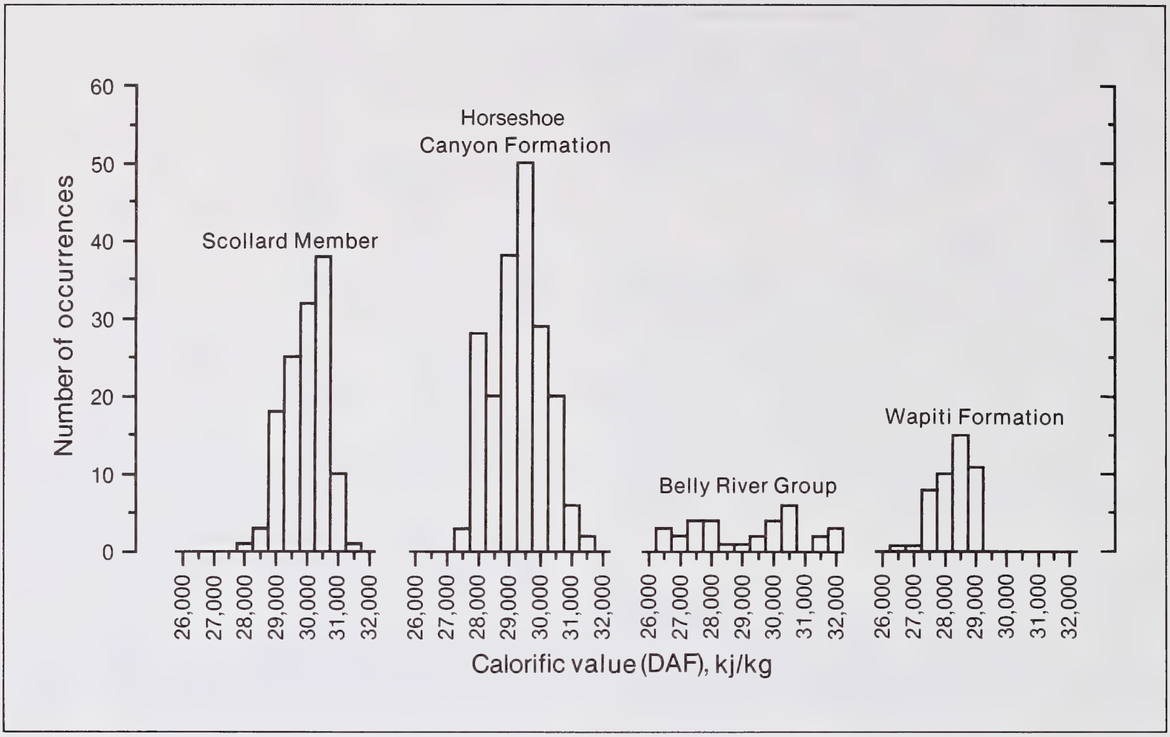

Figure 7. Distribution of calorific values (dry ash-free basis)

tion are positively skewed with a positive kurtosis (figure 8). The reason the Belly River Group does not have a similar distribution may be a function of the number of samples. More normal distributions occur if the sulfur percentages are transformed to their log [10] values. The minimums, maximums, means and 95 percent confidence intervals about the sample means, presented in table 2, are calculated from the transformed data.

Table 3. ASTM classification.

Rank	Calorific value (kj/kg) Equal to or greater than	Less than
High Vol. Bituminous A	32564*	-
High Vol. Bituminous B	30238	32564
High Vol. Bituminous C	26749	30238
	24423	26749**
Subbituminous A	24423	26749
Subbituminous B	22097	24423
Subbituminous C	19306	22097
Lignite A	14654	19306
Lignite B	-	14654

*Also based on fixed carbon and volatile matter.
**If agglomerating.

Comparison of results from cuttings and core samples

The analyses used in this study were of samples collected from both cuttings and cores from conventionally drilled testholes. Cuttings were subjected to a 1.8 specific gravity separation and the lighter fraction was analysed. Core samples were analysed as sampled. There is a statistical bias limiting meaningful comparisons between the two sample types: since the ash content is artificially lowered in the cuttings samples (cuttings mean = 22.1 percent, core mean = 34.3 percent) all parameters relating to ash content, particularly calorific value, will also be affected in the comparison.

Rank determination, however, is not influenced by this sampling method, as the calorific value is calculated to a mineral matter free basis.

A statistical comparison of the two sampling methods will not be attempted here. The interested reader is referred to Dyck *et al.* (1980) for their discussion of a similar comparison.

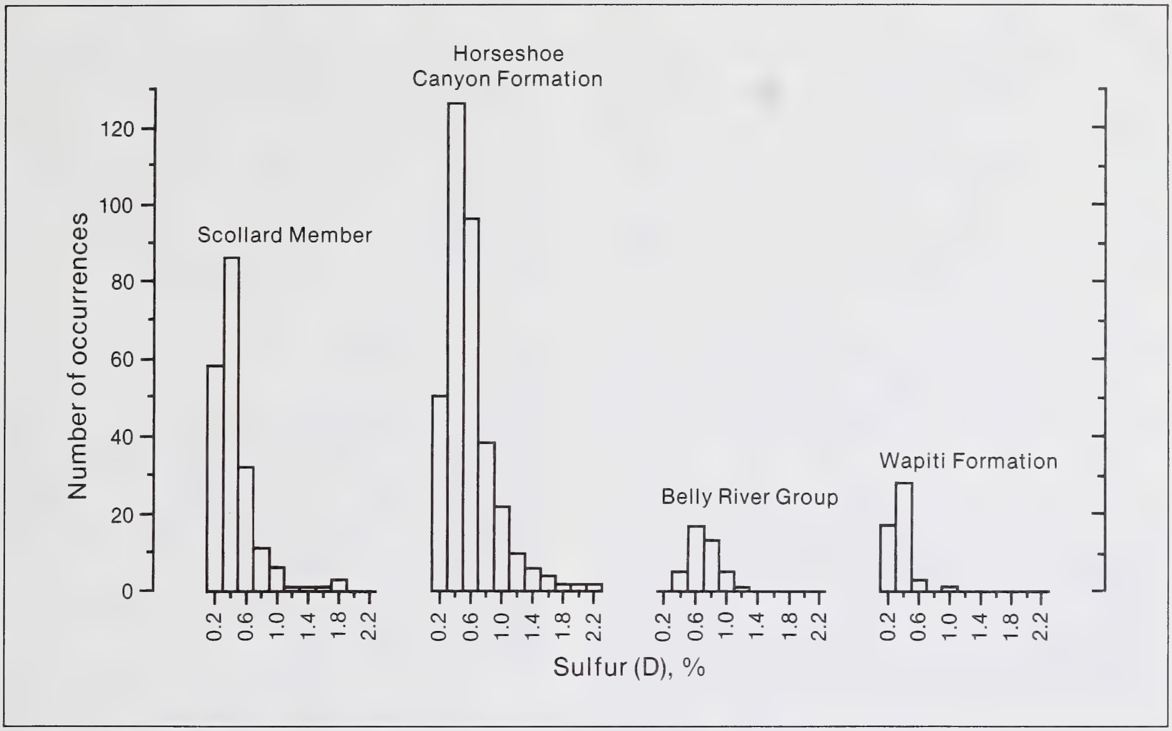

Figure 8. Distribution of sulfur percentages

Relationships between analysis components

Calorific value versus ash

A close inverse relationship exists between the calorific value (CV) of a coal sample and its corresponding ash content. A cross-plot of these variables, both expressed on a dry basis, is provided in figure 9. All data with ash (D) content less than 25 percent are plotted, regardless of coal-bearing unit. A least squares regression analysis of calorific value (D, kJ/kg) on ash (D, percent) yields the equation

$$CV(D) = 29269 - 286(ASH[D]). \qquad (1)$$

The correlation coefficient (R) between these variables is -0.89 (with $R^2 = 0.78$). The 95 percent confidence intervals around the calorific value estimation, (following the method described in Ezekiel and Fox [1959, figure 2.1]), the slope and the intercept are ± 1642 kJ/kg (706 Btu/lb), ± 14.6 and ± 227.0, respectively.

The calorific value data shown in the cross-plot (figure 9), and used in calculating the relationship between calorific value and ash, are from the entire plains area. The constant shown in equation 1, representing the calorific value at a theoretically occurring zero ash value, therefore represents an average calorific value for near-surface coals throughout the area sampled. The slope component of equation 1 indicates that calorific value (D) decreases by 286 kJ/kg (123 Btu/lb) for each percentage increase in ash (D) content.

Table 4 shows the results of both correlation coefficient and least squares regression analysis calculations for each of the coal-bearing units. Of particular interest is the lower correlation coefficient between

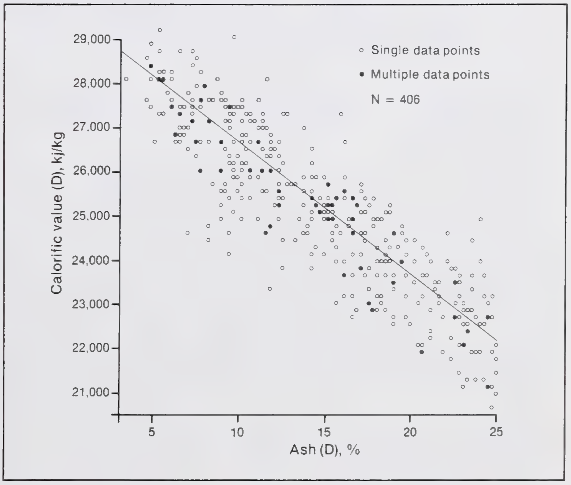

Figure 9. Cross-plot of calorific value (dry basis) versus ash (dry basis)

Table 4. Equations relating calorific value (dry basis, in kJ/kg) and ash (dry basis, in percent) for coal samples containing less than 25 percent ash

Coal-bearing unit	n	R	Equation
Scollard Member	128	-0.94	CV = 29955-301(ASH)
Horseshoe Canyon Fm	197	-0.94	CV = 29668-318(ASH)
Belly River Group	32	-0.65	CV = 27720-203(ASH)
Wapiti Formation	47	-0.87	CV = 28375-286(ASH)

calorific value and ash for the Belly River Group (R = − 0.65) compared to the remaining coal-bearing units (with R = − 0.87 to − 0.94). The reason for this lower correlation coefficient may be that the Belly River Group coals were sampled over a considerable distance in an east-west direction (figure 2). This areal variation in sample location introduces a substantial change in calorific value because of increasing rank (hence an increasing degree of maturation) in a westerly direction. In contrast, Horseshoe Canyon Formation and Scollard Member coals were sampled in a narrow north-south band following the outcrop of the formations. In the Belly River Group therefore, sample locations affect the ash/calorific value relationships more than in other coal-bearing units.

Equilibrium moisture versus ash

The calculated correlation coefficient (R) between equilibrium moisture and ash (D) content is − 0.38; this correlation coefficent indicates that samples with higher ash have lower equilibrium moisture. With 419 samples used in its calculation, this value of correlation coefficient (R = 0.38) is statistically significant, Dyck *et al.* (1980) calculated a correlation coefficient of − 0.90 for equilibrium moisture and ash (D) content for 1176 samples of Saskatchewan lignites. The correlation coefficient of Dyck *et al.* (1980) is considerably higher than that calculated in this study. A possible reason for this difference will be discussed later.

Calorific value versus equilibrium moisture

The calorific value of a coal sample, expressed on a moist mineral matter free basis, is affected by the equilibrium moisture of the sample; therefore, a correlation between calorific value (MMF) and equilibrium moisture is to be expected. A correlation coefficient (R) of − 0.91 (R^2 = 0.83) was calculated for these variables for all data regardless of coal-bearing unit. A cross-plot of these variables is presented in figure 10. A least squares regression analysis of calorific value (MMF, kJ/kg) on equilibrium moisture (MEQ, percent) yields the equation

$$CV(MMF) = 31816 - 442(MEQ). \qquad (2)$$

The 95 percent confidence intervals around the calorific value estimation, the slope, and the intercept are ± 1408 kJ/kg (605 Btu/lb), ± 25.2 and ± 456.8, respectively.

This relationship (shown in figure 10) indicates the significant degree to which moisture content and coal rank are interdependent. This interdependence is a well documented feature of low rank coals (Teichmüller and Teichmüller 1968, p. 248). The slope component of equation 2 indicates that calorific value (MMF) decreases by 442 kJ/kg (190 Btu/lb) per percent increase in moisture content.

Volatile matter and fixed carbon versus calorific value

The correlation coefficient between volatile matter (DAF) content and calorific value (DAF) is − 0.31. This correlation coefficient indicates that an increase in calorific value is associated with a decrease in volatile matter content (or, conversely, with an increase in fixed carbon content).

These relationships have been known for some time and are discussed in detail by Teichmüller and Teichmüller (1968) and Berkowitz (1979). The values of correlation coefficient (R = ± 0.31) are statistically significant with n = 402.

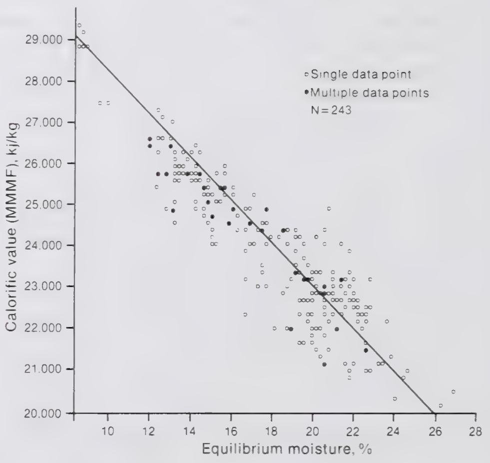

Figure 10. Cross-plot of calorific value (moist mineral matter free basis) versus equilibrium moisture

Proposed model to explain coal rank variation

Coals within the plains area of Alberta vary in rank; implicit in this variation is a variation in coal quality. The Energy Resources Conservation Board indicates that within 600 m of the surface, coals in the plains area are mainly subbituminous B and C in rank, increasing to subbituminous A at the western edge of the plains area and to high volatile bituminous C in the Lethbridge area (ERCB, 1983). The range of coal rank variation found in this study, however, appears to be considerably greater: both Upper Cretaceous and Tertiary coals attain ranks as high as high volatile bituminous C in the central plains area, at depths generally less than 300 m (table 2). An understanding of the mechanism that creates this variation would be helpful to the coal industry: exploration could then be concentrated in areas predicted to contain high quality coals.

Traditionally, coal scientists working in the plains area have explained the variations in coal rank as being controlled by tectonism (Stansfield and Lang, 1944; Campbell, 1972, 1983). This model, however, does not adequately explain the occurrence of "anomalous" high rank coals in the plains area. An alternative model is proposed. This new model states that a coal seam rank is related to its original depth of burial and that the variation in rank noted in the plains area is due to varying amounts of overburden that existed when the coals reached their current maturity.

Tectonic model

The increase in coal rank in a westward direction (towards the mountains) has been known for some time and is well documented by Stansfield and Lang (1944), Steiner, Williams and Dickie (1972), and Campbell (1972, 1983). Stansfield and Lang (1944, maps 6 through 10) found that calorific value decreased and moisture content increased in a direction away from the mountain front. In order to explain this phenomenon, they state (p. 9), "the rank of coal is primarily dependent upon the mountain building pressure to which it has been subjected, and only to a lesser degree dependent upon its geologic age or the depth of the seam below the surface." Using data from Stansfield and Lang (1944) and Campbell (1964, 1966), Steiner, Williams and Dickie (1972) contoured the moisture content of coals in the plains and foothills area and found that moisture decreased from 30 percent in the central to eastern plains area to near 10 percent for the Coal Valley area. An explanation for this decrease was not provided.

Campbell (1972) recognized a decrease in coal rank with an increasing distance from the mountain front, as well as an increase in rank with depth, at a calculated rate of 5.34 kJ/kg per metre of depth (0.7 Btu/lb/ft). In providing a mechanism to explain the rank patterns found in the plains area, Campbell (1983) states "the uplift of the Cordillera ... was accomplished by a continuous horizontal force ... that could metamorphose the coal just as effectively as overburden weight" (p. 2).

The factors thought to control rank of plains coals do not, however, adequately explain the existence of relatively high rank coals in the central plains. If coal rank in the plains area of Alberta was related to heat and/or pressure generated from the uplift of the Rocky Mountains, coals in the foothills region should be considerably higher in rank than those found in the central plains. This is not the case. Coals equivalent in age to those occurring in the Scollard Member in the plains area are mined in the Coal Valley area in the foothills (ERCB, 1983). Equilibrium moisture content and calorific value (MMMF) of the Coal Valley coals vary from approximately 8.5 to 10 percent and 27 905 to 28 424 kJ/kg (11,997 to 12,220 Btu/lb) (Mervyn Rogan, Luscar Ltd., personal communication, 1982; Steiner, Williams and Dickie, 1972). Coal quality parameters approaching these values have been calculated for samples from Upper Cretaceous and Tertiary coals in the plains (figure 6, table 2).

Alternative model

Hilt's rule, a fundamental rule in coal geology states that in undisturbed strata, the rank of coal increases with increasing depth of burial. The coals discussed in this study lie within the eastern limb of the Alberta Syncline and are undeformed by folds or faults related to tectonism. (Local areas have experienced some sediment deformation caused by glacial action but this deformation is limited to shallow depths.) The coalification model presented in this study follows Hilt's rule in that it proposes that rank variations of the plains coals can be related to original depth of burial. This model considers both examples of coalification models developed elsewhere and the geological history of western Canada.

Teichmüller and Teichmüller (1968) and Stach *et al.* (1975) provide excellent examples supporting the concept of increasing rank with increasing depth of burial. These borehole studies indicate that coals within the subbituminous and bituminous ranks decrease in volatile matter and moisture content and increase in carbon content, calorific value and vitrinite reflectance with increasing depth. In undisturbed strata an increasing depth of burial facilitates coalification in two ways: by increasing temperature, at a rate equal to the geothermal gradient, and by compaction, through increasing overburden pressure. The increasing temperature is considered to be responsible for chemical maturation (Berkowitz, 1979), the degree of which can be determined by measuring the vitrinite reflectance. Increasing pressure, which has been shown to inhibit, or even retard, chemical maturation (Teichmüller and Teichmüller, 1968; Stach *et al.*, 1975), is associated with physical-structural changes in coal (Teichmüller and Teichmüller, 1968). In a subsiding basin such as the plains of Alberta, the physical-structural changes should occur in parallel with the chemical changes.

Increasing rock density (or decreasing pore volume) is commonly linked to increasing depth of burial (Magara, 1979; Teichmüller and Teichmüller, 1968); a

similar compaction phenomenon occurs in coals (the physical-structural changes noted above). Berkowitz (1979) relates equilibrium moisture content of coals with coal porosity (pore volume). The in situ moisture content of coals should, therefore, reflect the pressures to which the coals have been subjected.

In his study of the maturation of Mannville sediments, Hacquebard (1977) used equilibrium moisture data from Steiner, Williams and Dickie (1972) to predict original depths of burial for oil and gas fields in Alberta. The relationship between moisture content and depth of burial, shown in figure 11, was taken from European research. This graph indicates a logarithmic decrease in bed moisture (equilibrium moisture [MEQ, percent]) with respect to an increase in depth of burial (DOB, m). By estimating values from both axes of the graph, this graph can be translated to the formula

$$\log 10\,MEQ = 1.865 - 0.000416(DOB). \qquad (3)$$

It should be noted that the coal rank divisions indicated in figure 11 are slightly different from those encountered in this study. The relationship between equilibrium moisture and depth of burial for coals in the Alberta plains will be discussed later.

With equation 3, the maximum depth of burial was calculated for all coal samples with ash contents less than 25 percent for which equilibrium moisture data were available. A cross-plot of calorific value (MMMF) versus the calculated depth of burial (figure 12) shows that, as predicted by Hilt's rule, coal increases in rank with an increase in depth of burial. Hacquebard (1977) indicated a logarithmic relationship between equilibrium moisture and original depth of burial (figure 11, equation 3); the present study documents an inverse linear relationship between equilibrium moisture and calorific value (MMMF). The relationship between original depth of burial and calorific value should not, therefore, be linear. Because of the small range of depth of burial values calculated (1200 to 2200 m [3937 to 7218 ft]), however, the relationship appears linear (especially for the calorific range 22 000 to 29 000 kJ/kg) and a simple least squares regression analysis can be performed. This regression analysis yields the equation

$$CV(MMMF) = 14748 + 6.25(DOB). \qquad (4)$$

The slope component of this equation indicates that plains coals increase in calorific value (MMMF) at a rate of 6.25 kJ/kg/m (0.82 Btu/lb/ft) of depth (or overburden). This rate of increase represents the coalification gradient. Equation 4, or the coalification gradient, cannot be used for coals with ranks beyond the calorific value range of 22 000 to 29 000 kJ/kg because of the curvilinear relationship between depth of burial and coal rank.

Campbell (1972), using coal samples from deeper oil wells, calculated a coalification gradient of 5.34 kJ/kg/m (0.7 Btu/lb/ft) for the Alberta plains area. However, this lower gradient was calculated on the basis of an assumed linear relationship between rank and depth, for the range of coal ranks between subbituminous and high volatile bituminous A. As discussed above, the assumption of a linear relationship

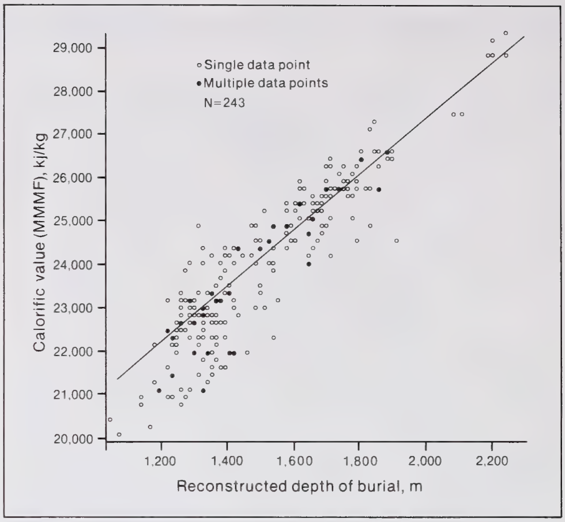

Figure 12. Cross-plot of calorific value (moist mineral matter free basis) versus depth of burial at time of maximum coalification

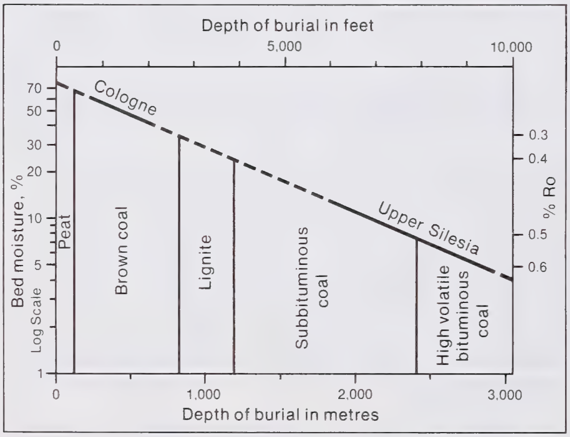

Figure 11. Relationship of moisture content in coal and its original depth of burial (from Hacquebard, 1977)

Table 5. Required thickness of overburden. The calculation for subbituminous A coal assumes coal is non-agglomerating

Coal rank (ASTM)	Required overburden (metres)
Subbituminous C	- 1176
Subbituminous B	1176 - 1548
Subbituminous A	1548 - 1920
HV Bituminous C	1920 -

for such a considerable calorific value range cannot be made.

With the use of Equation 4, the overburden required to produce various low rank coals can be calculated (table 5). This equation can also be used to modify Hacquebard's (1977) diagram (figure 11) to include the coal ranks found in the Alberta plains (figure 13).

Once the original depth of burial of a coal sample has been calculated, the amount of sediment removed above the coal sample can be determined by subtracting the present depth of the sample from its original depth of burial. In order to present these data in map view, and to remove some of the statistical variation in the data, the coal-bearing portion of the plains (as defined by figure 1) was divided into blocks, each nine townships in area (840 km² [324 mi²]) and an average value of removed overburden thickness was calculated for each block (appendix 4). Figure 14 shows that the

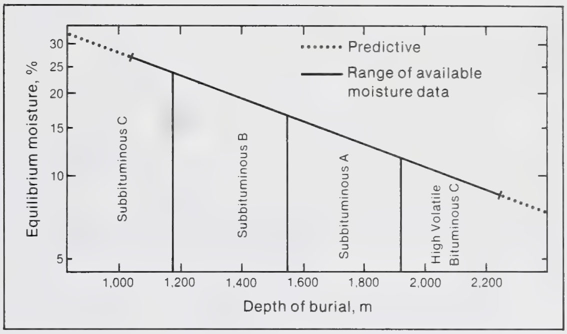

Figure 13. Modification of Hacquebard's (1977) diagram showing the relationship of moisture content in coal and its maximum depth of burial for the coal ranks found in the plains area of Alberta

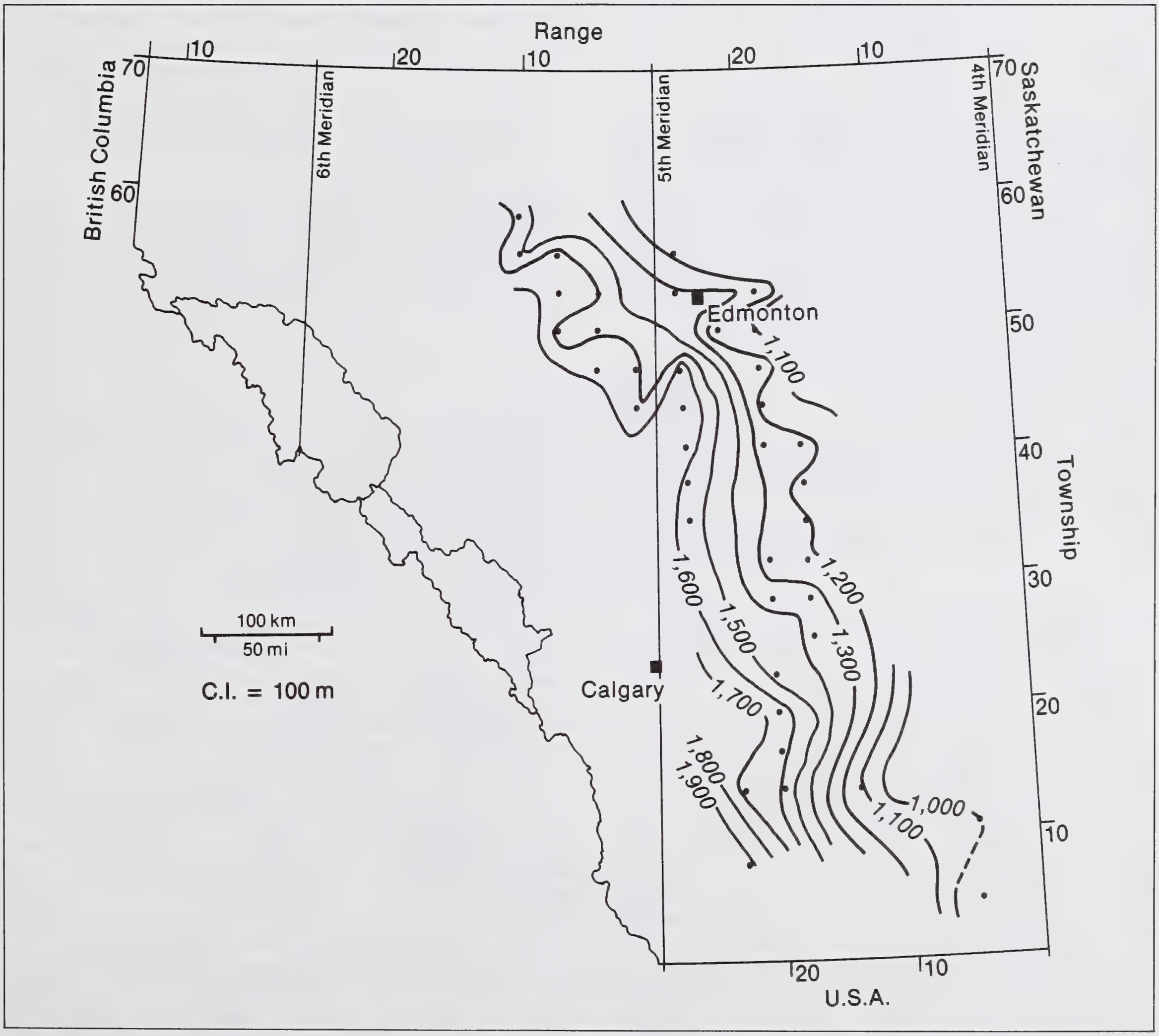

Figure 14. Thickness of removed sediment from the plains area of Alberta

amount of removed overburden varies from approximately 900 m (2950 ft) in the east to approximately 1900 m (6230 ft) in the western plains area.

Cross section A-A′ (figure 15), constructed through the plains from northeast to southwest (figure 1), indicates the subsurface stratigraphy, the westerly dip of the coal-bearing units and the reconstructed maximum paleotopographic surface. This surface was determined by adding the calculated amount of removed overburden to the present land surface. When the calculated maximum paleotopographic surface existed, plains coals would have reached their maximum (and current) degree of metamorphism. As noted in table 5, high volatile bituminous C coals require at least 1920 m (6300 ft) of burial. A line 1920 m (6300 ft) below the maximum paleotopographic surface, shown in cross section A-A′ (figure 15), should therefore separate the occurrence of bituminous coals from subbituminous coals in the subsurface. A similar method of calculation can be used to determine the theoretical occurrence of the subbituminous ranks of coal in the subsurface. This has been done in cross section B-B′, which is constructed east to west through southern Alberta (figure 16). Both cross sections A-A′ and B-B′ (figures 15 and 16) show that coals occurring near the present land surface would increase in rank in a westerly direction.

In a study of Saskatchewan lignites, equilibrium moisture content and ash content had a correlation coefficient of R = −0.90 (Dyck *et al.*, 1980), which is considerably higher than the correlation found in the present study (where R = −0.38). This study suggests that the variation in equilibrium moisture in coals from the plains area of Alberta can be related to the variation in coal seam depth of burial, which varies according to the sample location. Because of the good correlation between equilibrium moisture and ash in the Saskatchewan study, other factors affecting the lignites equilibrium moisture, such as variation in depth of burial, played a lesser role.

Suggate and Lowery (1982) note that coals with similar equilibrium moisture contents have higher ranks in areas with higher geothermal gradients. Coals with similar equilibrium moistures must have been subjected to similar compaction histories (or similar depths of burial). Coals from areas with higher geothermal gradients are higher in rank, therefore, because these coals reached higher levels of chemical maturation. Comparison of figures 11 and 13, shows that the coals occurring in the plains area of Alberta (figure 14) appear to mature at shallower depths. This would indicate that the regional geothermal gradient at the time of maximum burial was probably higher in the plains area of Alberta as compared to the area described by Hacquebard (1977). Hitchon (1984) discusses present and past geothermal gradients in the plains area.

Geologic considerations

An analysis of the geological history of western Canada indicates that the model proposed for coal rank variation is very plausible. Taylor, Mathews and Kupsch (1964) indicate that Paleocene sediments (lower

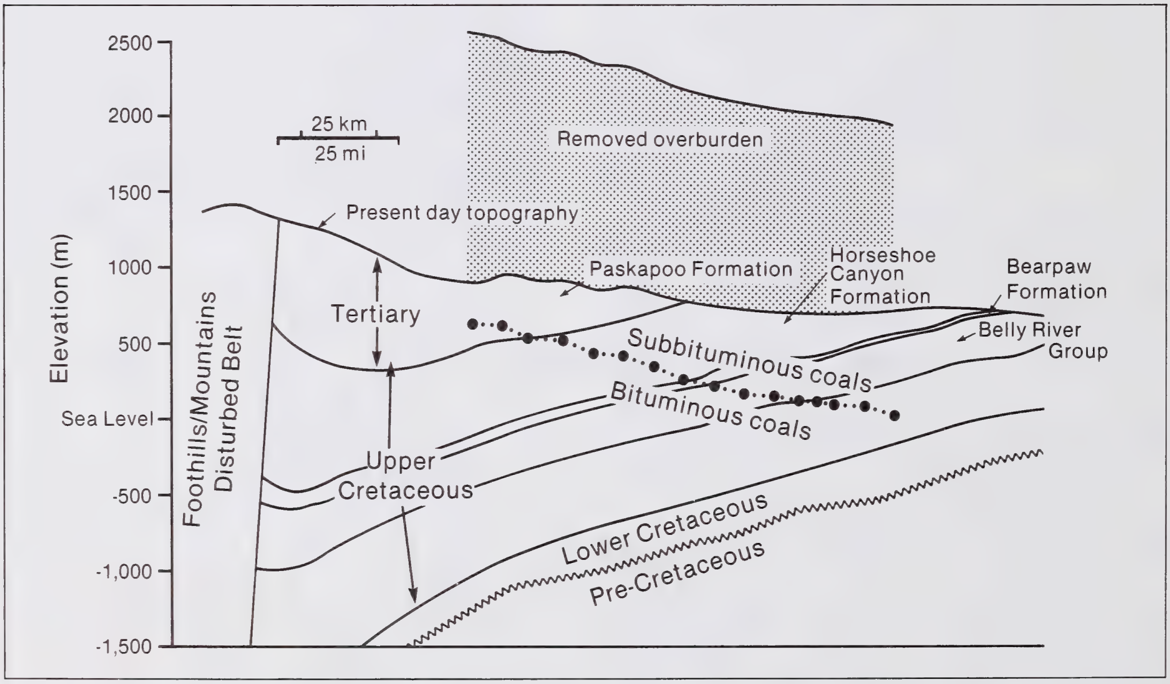

Figure 15. Cross section A-A′ trends northeast through the central plains area and shows both the reconstructed overburden and the west southwest dip of the coal-bearing units. The subsurface stratigraphy is modified after Gussow (1962)

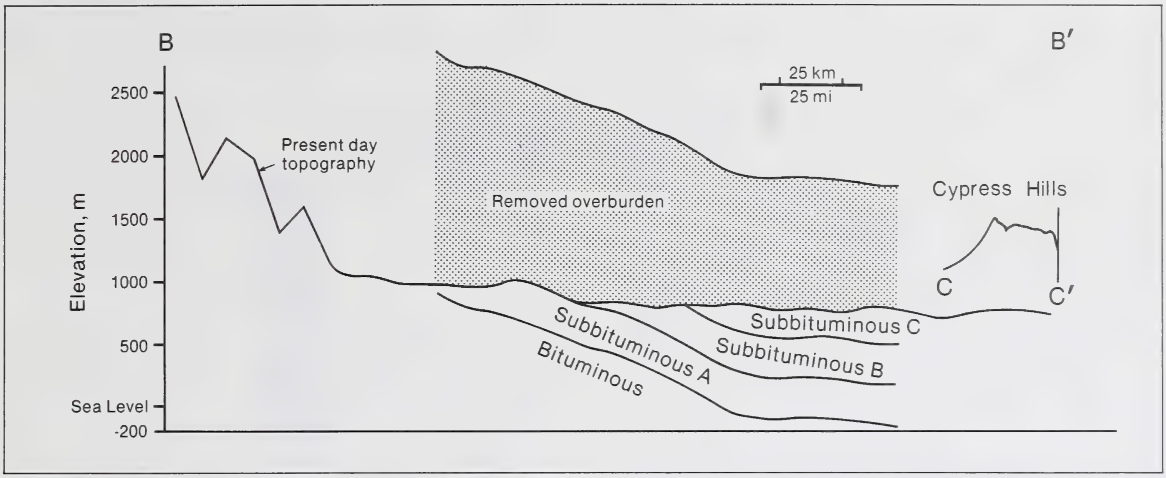

Figure 16. Cross section B-B′ shows the present surface elevation through township 13, the thickness of removed overburden (from figure 14) and the relationships of coal rank as they should occur in the subsurface. Cross section C-C′ shows the present elevation of the Cypress Hills, through township 8

Tertiary) attain a thickness of over 1500 m (4900 ft) in portions of the westernmost interior plains; it is very possible that equivalent sediments extended eastward in the past. In addition, sediments derived from the uplift of the Rocky Mountains during the Eocene and Oligocene periods (Taylor, Mathews and Kupsch 1964) would have provided additional sediment thickness. Price and Mountjoy (1970) differ from Taylor, Mathews and Kupsch, (1964) in their interpretation of the structural development of the eastern Rocky Mountains. Price and Mountjoy suggest that the major thrusting culminated during the Paleocene period, and not during the Eocene and Oligocene periods, as suggested by Taylor, Mathews and Kupsch, (1964). Regardless of their views on the structural development of the easternmost Rocky Mountains and westernmost plains, both authors support the idea of a blanket of Eocene-Oligocene sediments covering the plains area. Significant portions of this Tertiary sediment, as well as portions of Upper Cretaceous sediment, were subsequently eroded.

The elevation and stratigraphy of the Cypress Hills in southeast Alberta can be used to demonstrate that a significant thickness of sediment has been removed from the plains area. These hills, which are capped by a coarse Oligocene conglomerate, stand up to 700 m (2300 ft) above the surrounding plains. The calculated thickness of sediment that would have been required to mature the coals found northwest of the Cypress Hills has been plotted on cross section B-B′ (figure 16). If the maximum paleotopographic surface on cross section B-B′ were projected southeast towards the Cypress Hills (cross section C-C′, figure 16), it would fall approximately 180 m (590 ft) above the summit of these hills. It is reasonable to suggest that this amount of sediment may have been eroded from the top of the hills during the last 30 million years.

Geophysical logs from petroleum boreholes located in the Cypress Hills (6-3-8-2-W4M), and outside the hills (11-16-13-3-W4M) on cross section B-B′, were examined to determine the thickness and age of sediment eroded in areas away from the Cypress Hills (figure 17). Because of the scarcity of wells in the Cypress Hills area, trends of formation thickening or thinning could not be determined. Calculations of sediment removal assume that all rock units remain constant in thickness. A comparison of the two boreholes and a reference to the Geological Map of Alberta (Green, 1972) indicates that 45 m (148 ft) of Belly River Group, 336 m (1104 ft) of Bearpaw Formation, 57 m (186 ft) of Horseshoe Canyon Formation equivalent[2], 7 m (22 ft) of Battle Formation and at least 218 m (717 ft) of post-Battle Formation sediments have been removed from the vicinity of the 11-16 borehole. When the thickness of sediment removed from the Cypress Hills since Oligocene time is excluded, the calculations show that at least 678 m of sediment have been removed from the area of the 11-16 borehole.

The calculations of sediment removal in the vicinity of the Cypress Hills appear reasonable. Consequently, the estimated amount of sediment removed from the contoured area (figure 14) is probably not excessive.

Using sonic transit times in shales to estimate the degree of compaction, Magara (1978) also calculated the thickness of sediment that was eroded from the plains of Alberta. The thicknesses calculated, however, are considerably less than the thicknesses presented here. Magara's (1978, p. 44) cross section III-III' trends approximately northeast in the southern part of Alberta. At a point on this cross section approximately 14 km (9 mi) north of the city of Medicine Hat (point M in figure 1), Magara (1978) calculated approximately 176 m (577 ft) of sediment erosion. This erosion indicates a maximum paleotopographic elevation of 908 m (2977 ft). The Cypress Hills, 68 km (42 mi) southeast of point M (figure 1), have an elevation of 1465 m (4807 ft). These two locations should have had similar elevations during Oligocene time when sediments were actively being

[2]known as the Eastend Formation in the Cypress Hills area (figure 2).

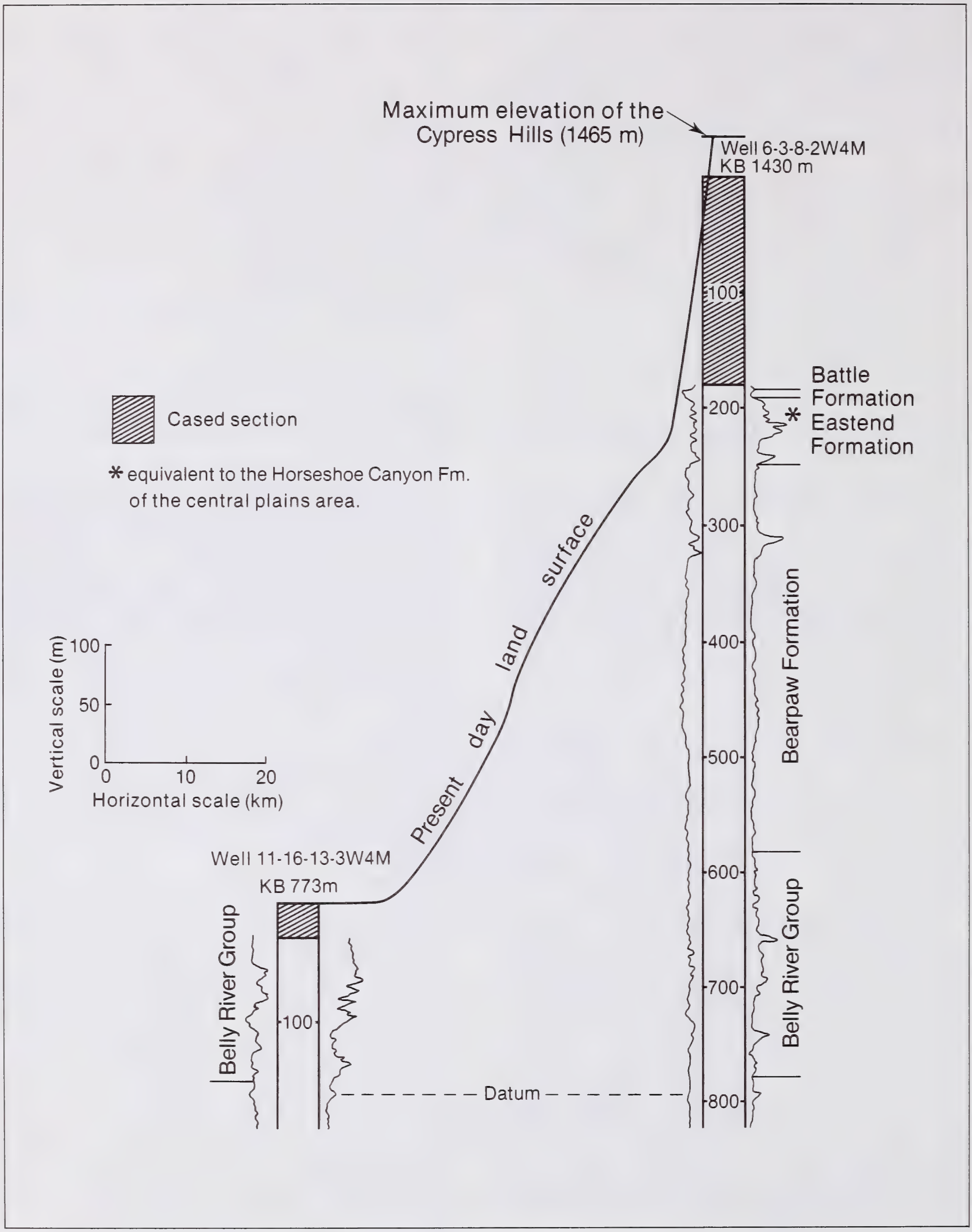

Figure 17. Cross section D-D′ trends north-south and runs from the Cypress Hills toward cross section C-C′. It indicates the approximate thickness and age of sediment eroded in areas surrounding the Cypress Hills

shed easterly from the foothills and mountains. Magara's (1978) estimates, therefore, appear to be too low.

The rate of erosion necessary for the removal of the calculated thickness of sediment is not unrealistic. If we assume an erosion time of 30 million years (middle Oligocene time to present), then the central plains area of Alberta underwent erosion at rates between 33 and 63 mm (1.3 and 2.5 in) per 1000 years. These values match well with the overall denudation rates calculated for the Mississippi drainage basin: 46 mm/1000 years for post-Jurassic erosion (Menard, 1961).

The proposed model for coal rank distribution in the plains area of Alberta suggests that coal increases in rank towards the west (that is, toward the mountain front) because coals in that direction were more deeply buried. Since the coals reached their present maturity (probably during the mid-Tertiary period), erosion has removed up to 1900 m of sediment, with the greater amount of erosion occurring in a westward direction. This westward increase in rank is in part shown by the higher average rank of Scollard Member coals compared to Horseshoe Canyon Formation coals (table 2; subbituminous A versus subbituminous B, respectively); Horseshoe Canyon Formation coals generally occur to the east of Scollard Member coals.

The similarity in rank of coals found in the Coal Valley area and of those found in the subsurface of the central plains area can be explained by the proposed model. Since the Coal Valley area was uplifted during Paleocene or early Eocene time (Price and Mountjoy 1970; Taylor, Mathews and Kupstch, 1964), coals in this area would not have had the maturation benefit of the overburden added during Eocene and Oligocene time.

Ecomonic implications

The relationship between calorific value (MMMF) and depth of burial (equation 4) was used to determine the thickness of overburden required to mature various low rank coals (table 5). This information, combined with the map showing the thickness of removed sediment (figure 14), can be used both to define areas containing similar ranks of coal and to determine present depths to coals of higher ranks in the plains area. Since high volatile bituminous C coals require at least 1920 m (6300 ft) of burial (table 5), these coals should be found at or near the surface in areas where approximately 1920 m (6299 ft) of overburden have been removed, and at approximately 100 m (330 ft) below the surface where 1820 m (5970 ft) of overburden have been removed. For the plains area where near-surface data exists this method of calculation can be used to determine the minimum theoretical depth to high volatile bituminous C coals (figure 18). The depth to the subbituminous ranks of coal can be calculated in a similar manner.

According to ERCB (1983), 82 percent of the total area underlain by coal-bearing strata in Alberta occurs in the plains area south of Lesser Slave Lake. This study indicates that the majority of these coals may be within the bituminous ranks, not the subbituminous ranks, as had previously been suspected. The Geological Survey Department of the Alberta Research Council has currently undertaken a sampling program of Scollard Member coals from the Coal Valley area east toward the outcrop edge. It is intended that the samples collected be analyzed for both coal rank determination and vitrinite reflectance. The results of this study should:

1) provide information on the range of coal ranks from the eastern foothills to the central plains area
2) determine vertical reflectance and calorific value gradients
3) provide an insight as to the paleotemperatures to which the coals were subjected
4) provide information on paleogeothermal gradients

Because of depth of burial and paleotemperatures of sediment and oil and gas maturation, the results of this study will be of interest not only to the coal industry but also to the oil and gas industry.

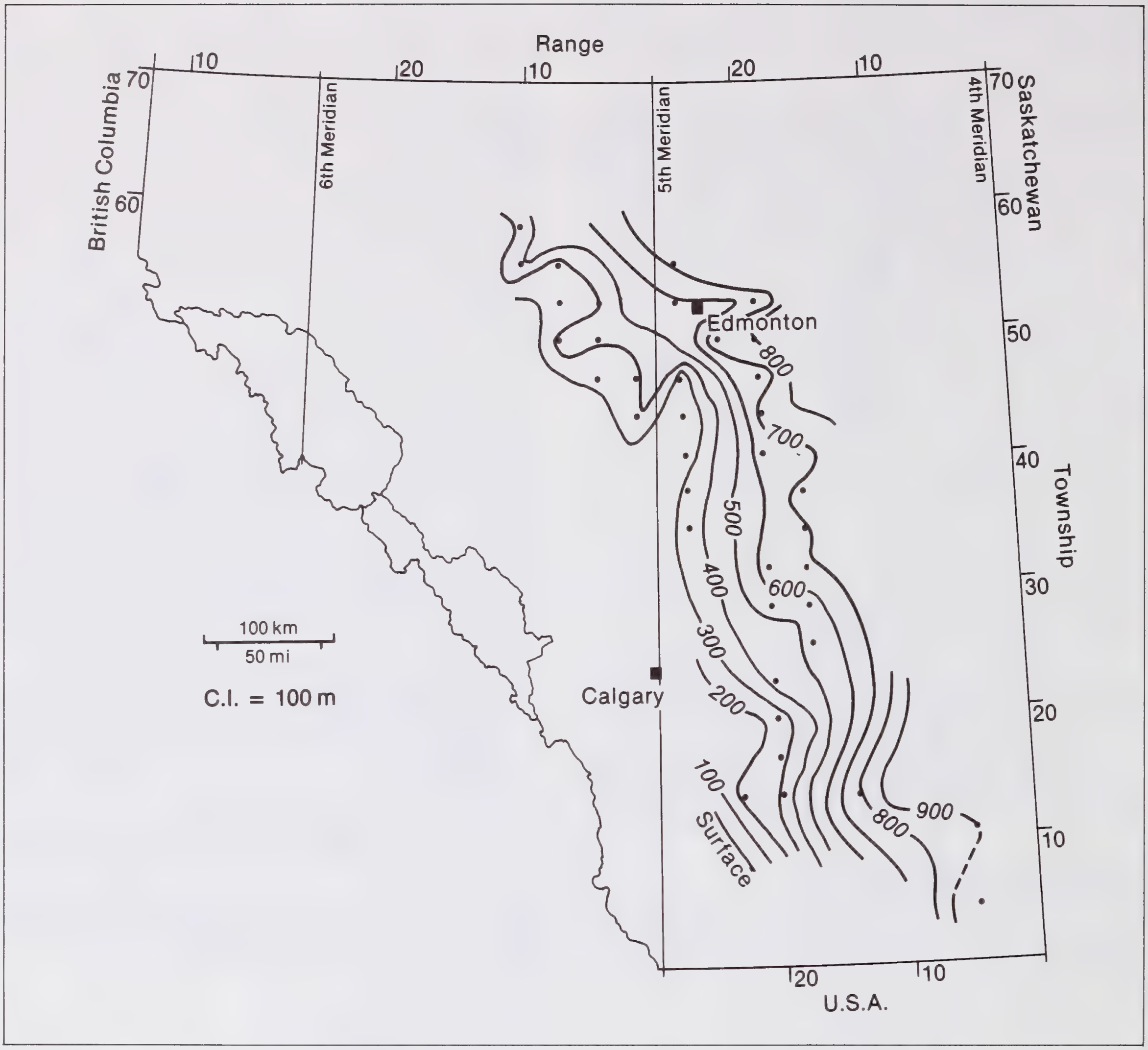

Figure 18. Calculated depth to high volatile bituminous C coals in the plains area of Alberta

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Appendix 1

Coal Analysis File

The 685 analysis enclosed in Appendix 1 are sorted first by land location, from south to north, and secondly by depth. The land locations on the following pages are presented in their conventional format, namely

LSD-SEC-TWP-RGE-MER

In order to minimize the amount of space required for Appendix 1, the following abbrevations are used.

Abbreviation	units	Parameter
COAL ZONE		Coal-bearing unit
SC-M		Scollard Member
HC-F		Horseshoe Canyon Formation
BR-G		Belly River Group
WP-F		Wapiti Formation
UNKN		unknown unit
UPPER DEPTH	m	upper sampling depth
LOWER DEPTH	m	lower sampling depth
SAMP TYPE		sample type
CUTT		cuttings
CORE		core
MOISTURE		moisture
AD	%	as determined moisture
AR	%	as received moisture
MEQ	%	equilibrium moisture
ASH	%	ash
VL-MATTER	%	volatile matter
DRY		dry basis
DMMF		dry mineral matter free basis
FX-CARBON	%	fixed carbon
CAL-VALUE	kJ/kg	calorific value
MMMF		moist mineral matter free basis
ULT-ANALYSIS		ultimate analysis
S	%	sulfur, dry basis
C	%	carbon, dry basis
H	%	hydrogen, dry basis
N	%	nitrogen, dry basis
O	%	oxygen, dry basis
COAL RANK		coal rank determinations
HVB-C		high volatile bituminous C
SUB-A		subbituminous A
SUB-B		subbituminous B
SUB-C		subbituminous C
INSF		insufficient data available

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-22- 3- 2W4M	BR-G	72.8	73.7	CUTT	5.6			26.3	36.4		37.3		20008		.82					INSF
7-31- 4- 4W4M	BR-G	184.1	184.1	CUTT			26.3	16.5	34.8	40.6	48.7	59.4	23702	20106	.90	60.90	3.80			SUB-C
1-29- 5- 6W4M	BR-G	86.5	87.8	CUTT	4.3			9.4	38.7		51.9		24646		.96					INSF
13-10- 7- 7W4M	BR-G	78.0	79.2	CUTT	4.2			13.1	41.3		45.6		24446		.90					INSF
13-10- 7- 7W4M	BR-G	90.5	92.9	CUTT	7.6			8.2	39.7		52.1		24514		.44					INSF
16-21- 8- 7W4M	BR-G	163.1	164.3	CUTT	5.0			20.7	35.7		43.6		21916		.94					INSF
5-19- 9- 5W4M	BR-G	94.2	95.1	CUTT	6.2			48.2	28.1		23.7		13512		.74					INSF
1-28- 9- 7W4M	BR-G	134.1	134.1	CUTT	4.2			24.7	34.8		40.5		20655		.80					INSF
1-28- 9- 7W4M	BR-G	134.1	134.1	CUTT	3.3			23.1	35.0		41.9		21206		.92					INSF
1-28- 9- 7W4M	BR-G	134.1	134.1	CUTT			26.9	32.7	30.9		36.4		18771		.70	48.30	3.20			INSF
4-35- 9-22W4M	BR-G	189.6	190.1	CORE	2.0	17.0	8.8	74.5	14.5		11.0		6541		.34					INSF
4-35- 9-22W4M	BR-G	190.1	190.5	CORE	4.2	12.4	9.6	24.5	35.6	45.7	39.9	54.3	23086	27449	.57					HVB-C
4-35- 9-22W4M	BR-G	190.5	190.8	CORE	3.0	9.7	9.0	11.5	39.2	43.6	49.3	56.4	28012	28775	.86					HVB-C
4-35- 9-22W4M	BR-G	190.5	190.8	CORE			12.6	12.6	36.4	40.8	51.0	59.2	27331	27133	.70	68.30	4.60			HVB-C
4-35- 9-22W4M	BR-G	190.8	191.1	CORE	2.6	16.8	8.8	16.1	37.1	43.3	46.8	56.7	26649	28905	.51					HVB-C
4-35- 9-22W4M	BR-G	191.1	191.4	CORE	2.6	16.0	8.5	9.6	39.1	42.7	51.3	57.3	29015	29356	.64					HVB-C
4-35- 9-22W4M	BR-G	191.4	191.7	CORE	3.1	10.8	8.8	23.5	34.7	43.8	41.8	56.2	24497	29108	.75	58.16	4.24	1.48	11.87	HVB-C
4-35- 9-22W4M	BR-G	191.4	191.7	CORE			14.1	24.3	32.2	40.9	43.5	59.1	23632	26228	.70	57.90	4.00			SUB-A
4-35- 9-22W4M	BR-G	191.7	191.8	CORE	2.6	10.4	8.8	40.9	27.6		31.5		18073		.77					INSF
4-35- 9-22W4M	BR-G	191.8	192.0	CORE	2.0	13.4	9.9	75.4	17.1		7.5		6078		.51					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-35- 9-22W4M	BR-G	192.9	193.3	CORE	2.6	10.5	8.5	24.0	36.7	46.7	39.3	53.3	24030	28882	1.19	58.12	4.33	1.38	10.95	HVB-C
5-22-11- 5W4M	BR-G	69.6	70.7	CUTT	6.2			11.4	40.1		48.5		24651		.75					INSF
16- 9-11- 6W4M	BR-G	51.2	53.3	CUTT	7.8			6.9	42.3		50.8		24639		.33					INSF
16- 9-11- 6W4M	BR-G	51.2	53.3	CUTT			26.9	12.1	36.1	40.3	51.8	59.7	25284	20429	.50	65.70	3.90			SUB-C
1-17-11-21W4M	BR-G	134.4	134.4	CUTT	2.3			48.8	24.7		26.5		14517		.54					INSF
1-17-11-21W4M	BR-G	134.4	134.4	CUTT			14.0	60.0	20.2		19.8		11188		.40	29.40	2.30			INSF
1-27-13- 8W4M	BR-G	95.4	96.0	CUTT	4.9			18.3	36.2		45.5		22872		.87					INSF
1-27-14-20W4M	BR-G	107.3	109.1	CORE	5.3	13.6	12.3	22.3	37.2	46.5	40.5	53.5	23867	26558	.83	58.62	4.24	1.51	12.47	SUB-A
1-27-14-20W4M	BR-G	107.9	110.9	CORE	5.5	16.3	12.8	23.5	36.5	46.3	40.0	53.8	22923	25688	.76					SUB-A
1-22-15-13W4M	BR-G	68.2	69.8	CUTT	4.8			16.4	35.5		48.1		22644		.75					INSF
13-24-15-14W4M	BR-G	75.3	75.3	CUTT	3.7			16.4	35.2		48.4		23167		.44					INSF
13-24-15-14W4M	BR-G	93.2	93.2	CUTT	3.1			7.6	40.3		52.1		25977		.72					INSF
13-24-15-14W4M	BR-G	93.2	93.2	CUTT			23.6	10.3	35.2	38.6	54.5	61.4	26470	22102	.60	67.30	4.00			SUB-B
13-23-15-21W4M	BR-G	250.0	250.0	CUTT	3.3			15.3	36.8		47.9		25188		.61					INSF
13-23-15-21W4M	BR-G	250.0	250.0	CUTT			16.7	20.8	34.1	41.7	45.1	58.3	23725	24318	.60	59.60	4.00			SUB-B
14-21-15-22W4M	HC-F	33.2	33.9	CORE	4.7	15.4	12.5	28.0	34.6		37.4		19862		.41					INSF
14-21-15-22W4M	HC-F	36.5	38.1	CUTT	5.1			12.1	37.9		50.0		25746		.54					INSF
14-21-15-22W4M	HC-F	55.1	55.1	CUTT	4.2			12.2	36.7		51.1		26030		.63					INSF
14-21-15-22W4M	HC-F	184.4	184.4	CUTT	3.1			51.4	23.9		24.7		13416		.41					INSF
14-21-15-22W4M	HC-F	184.4	184.5	CORE	3.7	11.1	11.6	42.5	29.1		28.4		16973		.45					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
14-21-15-22W4M	HC-F	184.5	184.7	CORE	2.6	8.8	7.7	73.6	14.5		11.9		6706		.20					INSF
14-21-15-22W4M	HC-F	184.7	185.0	CORE	3.1	10.4	9.2	62.5	21.8		15.7		10311		.24					INSF
14-21-15-22W4M	HC-F	185.0	185.3	CORE	4.7	13.5	11.1	52.3	23.4		24.3		14079		.37	34.87	2.75	.89	8.85	INSF
14-21-15-22W4M	HC-F	185.3	185.6	CORE	3.3	16.0	11.6	31.7	32.6		35.7		20257		.47					INSF
14-21-15-22W4M	HC-F	185.6	185.9	CORE	5.5	19.2	12.3	24.4	34.8	44.5	40.8	55.5	22644	25835	.39					SUB-A
14-21-15-22W4M	HC-F	185.9	186.0	CORE	2.2	22.2	6.2	62.4	14.9		22.7		11500		.99					INSF
16-20-16-11W4M	BR-G	94.8	94.8	CUTT	7.6			9.4	42.8		47.8		24135		.56					INSF
16-22-16-20W4M	BR-G	202.7	203.2	CORE	5.2	14.9	12.0	22.8	37.4	47.1	39.8	52.9	23632	26568	.69					SUB-A
16-22-16-20W4M	BR-G	204.2	204.5	CORE	4.8	22.3	12.0	18.8	36.0	43.2	45.2	56.8	24688	26470	.62					SUB-A
16-22-16-20W4M	BR-G	204.5	204.8	CORE	3.2	18.0	12.0	20.2	37.3	45.6	42.5	54.5	24449	26640	.54					SUB-A
16-22-16-20W4M	BR-G	213.2	213.4	CORE	4.8	15.8	15.6	10.0	38.5	42.2	51.5	57.9	27670	25712	.68	68.46	4.58	1.67	14.66	SUB-A
16-22-16-20W4M	BR-G	213.4	214.6	CUTT	3.2			19.3	37.1		43.6		24049		.66					INSF
16-22-16-20W4M	BR-G	213.4	213.6	CORE	3.1	13.9	12.1	34.1	29.2		36.7		19243		.69					INSF
13-15-17-19W4M	BR-G	149.0	149.3	CUTT	4.1			23.0	34.2		42.8		22955		.51					INSF
1-10-17-21W4M	HC-F	46.9	57.0	CUTT	3.4			10.1	36.9		53.0		26816		.63					INSF
1-21-17-22W4M	HC-F	110.6	110.6	CUTT	4.1			16.2	36.0		47.8		24784		.58					INSF
1-21-17-22W4M	HC-F	131.7	131.7	CUTT	4.5			5.7	38.0		56.3		27703		.49					INSF
13-21-18-20W4M	HC-F	28.9	30.1	CUTT	5.1			6.2	39.2		54.6		26679		.77					INSF
13-21-18-20W4M	HC-F	138.7	140.2	CUTT	4.5			20.7	37.4		41.9		23618		2.25					INSF
13-21-18-20W4M	HC-F	138.7	140.2	CUTT			17.2	29.1	31.4		39.5		20934		2.80	51.70	3.60			INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-21-18-23W4M	HC-F	267.3	271.3	CUTT	3.0			15.0	35.7		49.3		24974		.35					INSF
1-20-19-21W4M	HC-F	41.1	41.1	CUTT	4.5			17.8	36.3		45.9		22946		.55					INSF
1-20-19-21W4M	HC-F	57.6	57.9	CORE	4.1	15.3	13.3	16.4	38.7	45.4	44.9	54.6	24984	25600	.56	62.07	4.42	1.40	15.15	SUB-A
1-20-19-21W4M	HC-F	57.9	57.9	CUTT	3.8			7.9	39.4		52.7		27889		.77					INSF
1-20-19-21W4M	HC-F	57.9	58.2	CORE	6.1	16.9	14.6	5.9	40.5	42.7	53.6	57.3	28056	25346	.63					SUB-A
1-20-19-21W4M	HC-F	57.9	58.2	CORE	6.1	16.9	14.6	3.3	40.5	41.6	56.2	58.4	28056	24718	.63					SUB-A
16-21-19-22W4M	HC-F	181.4	181.4	CUTT	4.7			9.9	37.3		52.8		26128		.37					INSF
16-16-20-20W4M	HC-F	30.1	30.4	CUTT	3.3			42.5	26.3		31.2		15589		.51					INSF
16-16-20-20W4M	HC-F	76.2	80.4	CUTT	3.5			26.1	34.3		39.6		20501		.45					INSF
16-16-20-20W4M	HC-F	76.2	80.4	CUTT			16.8	32.2	29.7		38.3		19213		.30	49.20	3.30			INSF
13-11-20-21W4M	HC-F	44.8	45.7	CUTT	6.2			8.9	38.7		52.4		25565		.52					INSF
4-27-20-22W4M	HC-F	79.2	79.2	CUTT	3.4			18.0	34.9		47.1		23916		.54					INSF
4-27-20-22W4M	HC-F	189.0	189.0	CUTT	2.3			42.8	26.3		30.9		15935		1.58					INSF
4-27-20-22W4M	HC-F	198.1	198.1	CUTT	3.8			26.2	34.6		39.2		21495		.53					INSF
4-27-20-22W4M	HC-F	198.1	198.1	CUTT			18.5	38.0	28.4		33.6		17817		.30	45.10	3.10			INSF
4-27-20-22W4M	HC-F	211.8	211.8	CUTT	4.4			9.8	38.1		52.1		25637							INSF
16-22-22-21W4M	HC-F	168.9	170.1	CUTT	5.4			23.1	32.9		44.0		22046		.52					INSF
16-22-22-21W4M	HC-F	176.5	176.8	CUTT	3.9			38.0	28.0		34.0		16643		.30					INSF
16-10-22-22W4M	HC-F	179.8	179.8	CUTT	2.7			7.0	39.5		53.5		26509		.54					INSF
16-20-23-20W4M	HC-F	91.4	92.3	CUTT	3.1			26.6	31.5		41.9		20555		.43					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-20-23-20W4M	HC-F	93.5	94.2	CUTT	3.9			7.4	40.3		52.3		26388		.51					INSF
16-20-23-20W4M	HC-F	93.5	94.2	CUTT			20.4	10.6	36.0	39.6	53.4	60.4	26074	22839	.60	66.30	4.20			SUB-B
16-20-23-20W4M	HC-F	94.0	94.2	CORE	5.2	18.5	16.7	6.0	38.9	41.0	55.1	59.0	28305	24932	.73					SUB-A
16-20-23-20W4M	HC-F	94.2	94.5	CORE	4.0	18.8	17.5	4.4	42.6	44.3	53.0	55.7	28603	24567	.51					SUB-A
16-20-23-20W4M	HC-F	97.5	98.4	CUTT	2.8			29.2	36.2		34.6		19087		.78					INSF
16-20-23-20W4M	HC-F	97.5	97.8	CORE	4.2	21.6	17.5	4.7	39.8	41.5	55.5	58.5	28393	24453	.51					SUB-A
16-20-23-20W4M	HC-F	97.8	98.1	CORE	4.2	17.4	15.9	15.2	38.2	44.2	46.6	55.8	25156	24551	.45	62.91	4.24	1.29	15.87	SUB-A
16-20-23-20W4M	HC-F	97.8	98.1	CORE	3.8	17.1	15.0	18.9	36.2	43.5	44.9	56.5	23700	24379	.47	59.37	4.12	1.29	15.79	SUB-B
16-20-23-20W4M	HC-F	97.8	98.1	CORE			16.6	21.1	33.3	40.9	45.6	59.1	22469	23137	.40	57.50	3.90			SUB-B
16-20-23-20W4M	HC-F	98.1	98.5	CORE	4.0	19.8	17.3	6.9	38.1	40.5	55.0	59.5	27714	24430	.58					SUB-A
16-20-23-20W4M	HC-F	98.1	98.4	CORE	.5	12.8		97.1												INSF
16-20-23-20W4M	HC-F	98.5	98.6	CORE	.5	10.4		95.3												INSF
16-20-23-20W4M	HC-F	98.6	98.9	CORE	4.2	18.8	14.8	21.6	36.7	45.5	41.7	54.5	23144	24621	.66					SUB-A
16-20-23-20W4M	HC-F	98.6	98.9	CORE	4.4	16.9	14.6	23.1	37.7	47.7	39.2	52.3	22895	24853	.62					SUB-A
16-20-23-20W4M	HC-F	98.6	98.9	CORE			19.4	20.3	33.8	41.1	45.9	58.9	23074	22592	.60	58.10	3.90			SUB-B
16-20-23-20W4M	HC-F	98.9	99.2	CORE	4.4	20.5	16.1	9.2	41.6	45.3	49.2	54.7	27191	24895	.62	67.15	4.49	1.49	17.03	SUB-A
16-20-23-20W4M	HC-F	99.2	99.3	CORE	3.7	15.9	14.2	24.0	35.3	45.0	40.7	55.1	21918	24190	.59					SUB-B
16-20-23-20W4M	HC-F	99.3	99.4	CORE	3.3	16.6	15.1	18.9	36.3	43.6	44.8	56.4	23507	24146	.57					SUB-B
16-20-23-20W4M	HC-F	99.4	99.7	CORE	4.3	19.8	16.0	5.2	38.4	40.1	56.4	59.9	28200	24872	.69					SUB-A
16-20-23-20W4M	HC-F	99.7	99.9	CORE	4.6	18.3	15.4	11.0	38.4	42.4	50.6	57.6	26937	25358	1.21					SUB-A

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-20-23-20W4M	HC-F	99.9	100.1	CORE	1.5	13.0		92.5												INSF
16-21-23-21W4M	HC-F	114.3	115.2	CUTT	5.8			8.3	39.3		52.4		25774		.42					INSF
1-22-23-22W4M	HC-F	176.2	176.2	CUTT	4.2			29.0	31.6		39.4		20550		.49					INSF
1-22-23-22W4M	HC-F	188.7	188.7	CUTT	3.2			54.4	21.1		24.5		12158		.43					INSF
4-28-24-20W4M	HC-F	158.5	158.5	CUTT	6.4		16.2	37.4	28.3		34.3		17915		.98					INSF
14- 7-27-18W4M	HC-F	120.9	120.9	CORE	4.6		18.9	7.3	36.8	39.2	55.9	60.8	26696	23132	.64	68.88	4.61	1.49	17.08	SUB-B
14- 7-27-18W4M	HC-F	124.2	124.2	CORE	4.9		16.9	5.4	38.1	39.9	56.5	60.1	28093	24542	.63	71.78	4.80	1.49	15.91	SUB-A
14- 7-27-18W4M	HC-F	125.1	125.1	CORE	5.0		17.4	11.2	35.6	39.4	53.2	60.7	25616	23514	.68	66.56	4.40	1.38	15.81	SUB-B
14- 7-27-18W4M	HC-F	128.2	128.2	CORE	4.3		16.8	10.3	36.1	39.6	53.6	60.5	26233	24060	.78	67.27	4.68	1.44	15.56	SUB-B
14- 7-27-18W4M	HC-F	128.8	128.8	CORE	4.8		17.2	9.0	34.9	37.7	56.1	62.3	25644	23097	.80	68.21	4.28	1.09	16.62	SUB-B
14- 7-27-18W4M	HC-F	129.5	129.5	CORE	3.4		13.4	45.7	24.6		29.7		13984		.60	35.69	2.96	.84	14.21	INSF
15-33-27-18W4M	HC-F	70.3	70.3	CORE	5.7		19.6	6.5	38.2	40.4	55.3	59.6	27305	23269	.60	69.92	4.30	1.35	17.32	SUB-B
5-14-27-20W4M	HC-F	178.3	178.3	CUTT	6.4		14.4	38.1	24.8		37.1		17840		1.09					INSF
5-14-27-20W4M	HC-F	196.6	196.6	CUTT	7.2		14.1	28.5	29.9		41.6		20855		1.14					INSF
16- 9-28-18W4M	HC-F	64.0	64.0	CUTT	7.3		17.4	9.8	41.0	44.9	49.3	55.2	25849	23390	.60					SUB-B
1-24-28-19W4M	HC-F	74.8	74.8	CORE	3.9		16.1	35.3	28.8		35.9		19015		.52	47.80	3.37	1.18	11.89	INSF
1-24-28-19W4M	HC-F	88.7	88.7	CORE	5.4		18.7	7.3	39.9	42.6	52.8	57.4	27970	24304	.66					SUB-B
1-24-28-19W4M	HC-F	200.0	200.0	CORE	4.3		16.1	17.8	40.4	48.1	41.8	51.9	25393	25416	.70	62.81	4.88	1.55	12.27	SUB-A
16-21-28-20W4M	HC-F	182.3	184.4	CUTT	5.6		13.4	39.3	25.6		35.1		17794		.86					INSF
16-21-28-20W4M	HC-F	182.3	184.4	CUTT			16.1	12.2	37.5	42.0	50.3	58.0	26377	24888	.50					SUB-A

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-29-29-18W4M	HC-F	87.2	87.3	CORE	2.2	14.0		94.6	5.3		.1				.12					INSF
1-29-29-18W4M	HC-F	87.3	87.6	CORE	9.0	16.4	17.3	26.4	32.6		41.1		22030		.33					INSF
1-29-29-18W4M	HC-F	87.5	87.7	CORE	6.5	19.4	20.0	77.2	12.7		10.2				.12					INSF
1-29-29-18W4M	HC-F	87.7	88.0	CORE	7.8	17.8	16.4	37.7	27.9		34.4		18589		.27					INSF
1-29-29-18W4M	HC-F	88.0	88.3	CORE	9.5	21.2	19.1	8.0	38.2	41.0	53.9	59.0	27870	24232	.33					SUB-B
1-29-29-18W4M	HC-F	88.0	88.3	CORE			20.2	8.9	37.5	40.7	53.6	59.4	26656	23041	.30					SUB-B
1-29-29-18W4M	HC-F	88.3	88.6	CORE	9.7	17.6	18.6	12.3	36.6	41.0	51.2	59.1	26668	24330	.30					SUB-B
1-29-29-18W4M	HC-F	88.3	88.6	CORE				14.2							.30	64.00	4.10			INSF
1-29-29-18W4M	HC-F	88.6	88.9	CORE	9.0	18.3	17.9	14.0	36.9	42.2	49.1	57.9	25798	24188	.29					SUB-B
1-29-29-18W4M	HC-F	88.9	89.0	CORE	9.0	18.3	17.6	9.1	38.2	41.5	52.8	58.5	27691	24821	.38					SUB-A
1-29-29-18W4M	HC-F	89.0	89.2	CORE	3.8	16.8	12.7	85.8	11.1		3.2				.15					INSF
16- 6-29-19W4M	HC-F	104.5	104.5	CORE	5.5		19.2	5.3	36.8	38.5	57.9	61.5	28726	24342	.60	71.49	4.55	1.74	16.32	SUB-B
16- 6-29-19W4M	HC-F	119.4	119.4	CORE	5.2		18.7	6.2	39.0	41.2	54.8	58.8	26858	23097	.55	71.27	4.80	1.62	15.53	SUB-B
13- 1-30-17W4M	SC-M	111.2	111.2	CUTT	7.9		19.8	18.5	38.0	45.6	43.5	54.4	23718	22655	.68					SUB-B
16-21-30-18W4M	HC-F	153.6	153.6	CUTT	6.9		16.7	41.2	27.8		31.0		16761		.87					INSF
16-20-30-19W4M	HC-F	144.8	144.8	CUTT	5.7		15.6	40.6	27.8		31.5		16750		.83					INSF
1-27-31-17W4M	HC-F	72.5	73.4	CUTT	7.3		16.6	40.1	32.4		27.5		16540		.60					INSF
1-27-31-17W4M	HC-F	72.5	73.4	CUTT			20.5	35.4	32.0		32.6		17910		.30					INSF
1-27-31-17W4M	HC-F	147.8	147.8	CUTT	6.4		16.6	40.2	25.5		34.2		16805		.93					INSF
8-23-31-21W4M	HC-F	199.4	199.4	CORE	3.8		18.4	40.1	27.9		32.0		17250		.31					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
8-23-31-21W4M	HC-F	200.8	200.8	CORE	3.9		17.2	46.3	25.4		28.3		15370		.27	39.05	2.95	.87	10.59	INSF
8-23-31-21W4M	HC-F	202.2	202.2	CORE	4.5		18.0	10.1	38.7		51.2		27170							INSF
8-23-31-21W4M	HC-F	202.6	202.6	CORE	4.6		18.6	10.3	38.2	42.0	51.5	58.1	27228	24376	.61	67.94	4.44	1.40	15.36	SUB-B
8-23-31-21W4M	HC-F	216.7	216.7	CORE	4.5		17.8	11.2	37.7	41.8	51.1	58.2	27226	24856	.49	67.29	4.62	1.61	14.74	SUB-A
3- 5-31-24W4M	SC-M	93.0	93.9	CUTT	3.2			15.0	35.6		49.4		25723		1.19					INSF
3- 5-31-24W4M	HC-F	198.0	200.0	CUTT	2.1			26.8	32.3		40.9		22385		.73					INSF
3- 5-31-24W4M	HC-F	203.0	204.0	CUTT	2.5			25.7	34.3		40.0		22695		.62					INSF
4-26-31-25W4M	UNKN	100.3	101.6	CUTT	4.5			13.6	36.9		49.5		25633		.50					INSF
16-22-32-17W4M	HC-F	112.7	112.8	CORE	5.2	19.9		88.7	10.2		1.1				1.98					INSF
16-22-32-17W4M	HC-F	112.8	113.0	CORE	11.4	21.7	19.5	9.5	45.5	49.5	45.0	50.5	27372	24053	2.07					SUB-B
16-22-32-17W4M	HC-F	113.0	113.3	CORE	12.6	22.1	19.7	14.0	37.6	42.9	48.4	57.1	25453	23272	.63					SUB-B
16-22-32-17W4M	HC-F	113.3	113.6	CORE	10.7	21.3	19.6	20.5	37.4	45.8	42.1	54.2	23181	22681	.55					SUB-B
16-22-32-17W4M	HC-F	113.6	113.9	CORE	12.0	21.5	20.5	7.3	39.6	42.2	53.2	57.8	28403	24090	.66					SUB-B
16-22-32-17W4M	HC-F	113.9	114.1	CORE	7.3	20.0	16.9	68.4	17.9		13.7		7708		.37					INSF
16-22-32-17W4M	HC-F	120.4	120.5	CORE	2.9	12.6		93.5	5.6		.9				.15					INSF
16-22-32-17W4M	HC-F	120.5	120.8	CORE	13.5	22.7	21.5	9.5	40.6	44.4	49.8	55.7	26689	22797	.59					SUB-B
16-22-32-17W4M	HC-F	120.8	121.1	CORE	13.0	24.7	21.4	5.2	39.0	40.8	55.8	59.2	28156	23155	.55					SUB-B
16-22-32-17W4M	HC-F	121.1	121.4	CORE	12.9	23.1	20.9	4.7	39.3	40.9	56.0	59.1	28398	23414	.57					SUB-B
16-22-32-17W4M	HC-F	121.4	121.7	CORE	13.3	24.5	21.6	5.6	41.7	43.8	52.8	56.2	28263	23253	.46					SUB-B
16-22-32-17W4M	HC-F	121.7	122.1	CORE	12.6	22.4	19.6	5.5	39.9	41.9	54.7	58.2	28147	23758	.42					SUB-B
16-22-32-17W4M	HC-F	122.1	122.4	CORE	11.0	20.3	19.3	15.1	37.5	43.2	47.5	56.8	25202	23411	.52					SUB-B
16-22-32-17W4M	HC-F	122.4	122.7	CORE	12.8	21.4	20.1	7.1	40.7	43.4	52.2	56.6	27533	23437	.54					SUB-B
16-22-32-17W4M	HC-F	122.7	123.0	CORE	12.1	21.4	19.9	8.9	39.4	42.8	51.7	57.3	26691	23169	.58					SUB-B
16-22-32-17W4M	HC-F	123.0	123.2	CORE	9.3	24.7	18.7	62.3	19.1		18.5		9162		.28					INSF
16-22-32-17W4M	HC-F	123.2	123.4	CORE	13.0	21.6	20.0	10.1	38.7	42.5	51.2	57.5	26737	23441	.60					SUB-B
16-22-32-17W4M	HC-F	123.4	123.4	CUTT	8.0		20.0	22.3	36.7	45.7	41.0	54.3	21832	21636	1.62					SUB-C
8-28-32-19W4M	HC-F	17.9	18.9	CUTT	3.3			9.1	39.4		51.5		26495		.54					INSF
8-28-32-19W4M	HC-F	144.0	145.0	CUTT	3.7			28.5	33.5		38.0		20783		.60					INSF
8-28-32-19W4M	HC-F	164.0	166.0	CUTT	4.4			9.5	36.9		53.6		26188		.69					INSF
8-28-32-19W4M	HC-F	198.0	199.0	CUTT	4.2			19.8	37.0		43.2		22527		.55					INSF
16-22-32-23W4M	HC-F	102.1	102.1	CORE	3.1			17.0	40.6		42.4		25526		.46	62.69	4.65	1.32	13.88	INSF
16-22-32-23W4M	HC-F	103.6	103.6	CORE	3.5			14.0	41.5		44.5		26486		.52	65.41	4.51	1.33	14.26	INSF
16-22-32-23W4M	SC-M	105.0	106.0	CUTT	4.2			24.0	34.6		41.4		22632		.45	56.29	3.83	1.10	14.33	INSF
16-22-32-23W4M	HC-F	110.3	110.3	CORE	3.2			8.3	41.8		49.9		27544		.61	69.54	4.44	1.29	15.87	INSF
16-22-32-23W4M	HC-F	111.0	112.1	CUTT	3.8			24.2	34.6		41.2		22625		.46	56.68	3.86	.98	13.83	INSF
15-20-32-24W4M	SC-M	52.9	53.9	CUTT	3.9			14.3	35.1		50.6		25849		.31					INSF
16- 8-32-25W4M	SC-M	117.3	118.9	CUTT	6.4			24.3					23237		.90					INSF
16- 8-32-25W4M	SC-M	121.9	126.5	CUTT	6.5			16.9					25705		1.79					INSF
1-29-33-15W4M	HC-F	27.4	27.4	CUTT	7.6		21.8	46.0	26.9		27.1		14819		.82					INSF
4-27-33-17W4M	HC-F	100.6	102.1	CUTT	9.1		18.4	31.2	32.9		35.9		18855		1.26					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-14-33-18W4M	HC-F	129.5	129.5	CUTT	8.4		16.7	16.8	35.7	41.7	47.5	58.3	22827	22406	1.39					SUB-B
13-21-33-23W4M	SC-M	20.0	22.9	CUTT	4.5			11.5	36.5		52.0		26388		.54	66.21	4.06	1.12	16.57	INSF
1-18-33-26W4M	SC-M	170.7	175.6	CUTT	6.0			20.9					24088		.60					INSF
13-10-33-27W4M	SC-M	253.0	257.6	CUTT	5.6			26.1	28.1		45.8		22806		.84					INSF
16-21-34-17W4M	HC-F	131.0	133.2	CUTT			20.4	26.6	33.0		40.4		20794		.30					INSF
16-21-34-17W4M	HC-F	131.0	133.2	CUTT	9.3		20.3	31.9	30.9		37.2		18164		.69					INSF
16- 7-34-25W4M	SC-M	181.0	187.0	CUTT	3.6			15.2	36.4		48.4		25223		.31					INSF
16- 7-34-25W4M	HC-F	272.0	273.0	CUTT	2.3			34.3	31.1		34.6		19845		.44					INSF
16- 7-34-25W4M	HC-F	278.0	279.0	CUTT	2.6			22.1	37.6		40.3		23939		.50	58.52	4.22	1.08	13.59	INSF
13- 9-34-26W4M	SC-M	274.6	276.8	CUTT	5.1			23.5	29.1		47.4		23597		.37					INSF
1-21-35-16W4M	HC-F	60.3	60.5	CORE	8.0	31.5	20.7	66.9	18.7		14.5		8253		.29					INSF
1-21-35-16W4M	HC-F	60.5	60.8	CORE	12.0	20.9	20.5	16.2	42.7	50.1	41.1	49.9	23630	21816	.39					SUB-C
1-21-35-16W4M	HC-F	60.5	60.8	CORE			22.9	19.7	36.2	43.9	44.1	56.1	22725	20955	.30					SUB-C
1-21-35-16W4M	HC-F	60.8	61.1	CORE	14.2	23.7	21.5	18.1	42.5	51.0	39.4	49.0	22876	21201	.40					SUB-C
1-21-35-16W4M	HC-F	60.9	62.5	CUTT	8.6		22.5	31.7	36.5		31.8		18322		.96					INSF
1-21-35-16W4M	HC-F	61.1	61.4	CORE	12.6	22.1	21.1	7.7	46.4	49.9	46.0	50.1	26067	22006	.32					SUB-C
1-21-35-16W4M	HC-F	61.1	61.4	CORE			23.5	10.4							.30	66.30	4.00			INSF
1-21-35-16W4M	HC-F	61.4	61.7	CORE	13.7	23.9	22.6	5.2	45.6	47.8	49.3	52.2	26640	21548	.28					SUB-C
1-21-35-16W4M	HC-F	62.5	62.7	CORE	11.3	24.4	24.1	19.0	53.1	64.8	28.0	35.2	22488	20204	.37					SUB-C
1-21-35-16W4M	HC-F	62.5	62.5	CUTT	8.7		19.2	28.4	35.4		36.2		19415		.57					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-21-35-16W4M	HC-F	62.7	62.8	CORE	4.9	22.2	14.3	81.0	12.4		6.5				.23					INSF
1-21-35-16W4M	HC-F	149.8	149.9	CORE	4.1	17.7		88.3	8.2		3.5				.20					INSF
1-21-35-16W4M	HC-F	149.9	150.2	CORE	13.2	26.0	21.8	23.4	39.9	50.8	36.8	49.3	21343	20785	.44					SUB-C
1-21-35-16W4M	HC-F	150.2	150.6	CORE	13.5	24.9	21.7	20.6	35.7	43.8	43.7	56.2	22127	20976	.49					SUB-C
1-21-35-16W4M	HC-F	150.6	150.8	CORE	5.2	21.6	15.2	74.6	14.0		11.4		5755		.23					INSF
1-21-35-16W4M	HC-F	160.0	163.1	CUTT	8.0		20.0	36.6	38.3		25.1		17347		.90					INSF
1-28-35-17W4M	HC-F	112.8	112.8	CUTT	9.7		18.2	24.5	38.0	48.9	37.4	51.1	21064	21992	1.00					SUB-C
16-23-35-22W4M	SC-M	66.3	66.9	CUTT	5.6			14.3	34.2		51.5		24356		.59					INSF
13-14-35-24W4M	HC-F	169.0	170.0	CUTT	3.5			50.6	25.2		24.2		13379		.41	35.27	2.71	.68	10.36	INSF
13-14-35-24W4M	HC-F	171.0	172.0	CUTT	3.6			26.7	35.0		37.3		20978		.50					INSF
13-14-35-24W4M	HC-F	185.0	186.0	CUTT	3.8			19.4	34.8		45.8		23916		.47	60.61	4.05	1.08	14.30	INSF
12-15-35-25W4M	SC-M	193.5	198.1	CUTT											.38					INSF
8-27-35-26W4M	SC-M	218.9	226.2	CUTT	6.7			16.6	32.7		50.7		25349		.48					INSF
13-22-36-16W4M	HC-F	51.8	53.3	CUTT	9.9		20.6	20.5	37.9	46.4	41.6	53.6	21981	21176	1.11					SUB-C
4-25-36-17W4M	HC-F	100.6	102.1	CUTT	9.2		20.5	25.2	35.5		39.3		21227		1.28					INSF
2- 3-36-21W4M	SC-M	58.9	60.0	CUTT	5.5			18.0	35.5		46.5		23690		.85					INSF
2- 3-36-21W4M	SC-M	60.0	62.9	CUTT	5.2			12.2	37.0		50.8		25358		.38	65.04	3.89	.97	17.49	INSF
2- 3-36-21W4M	SC-M	76.0	78.0	CUTT	4.4			32.2	33.3		34.5		19424		.59					INSF
2- 3-36-21W4M	HC-F	122.0	123.0	CUTT	4.7			35.7	30.5		33.8		18154		.57	46.55	3.26	.86	13.10	INSF
4-14-36-22W4M	SC-M	37.9	40.0	CUTT	4.4			12.7	37.0		50.3		25795		.38					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-14-36-22W4M	SC-M	40.0	41.0	CUTT	4.1			23.6	33.1		43.3		22692		.44					INSF
4-14-36-22W4M	HC-F	115.0	116.0	CUTT	3.6			22.5	34.4		43.1		22772		.40	57.43	3.85	1.10	14.67	INSF
4-22-36-24W4M	SC-M	174.3	178.0	CUTT	7.3			39.7	33.2		27.1		17180		.30					INSF
15-22-36-25W4M	SC-M	168.4	168.7	CORE	3.2	10.9		92.9												INSF
15-22-36-25W4M	SC-M	168.7	169.2	CORE	8.5	19.0	15.1	25.7	29.5		44.8		22202		.55					INSF
15-22-36-25W4M	SC-M	171.5	172.1	CORE	8.3	19.4	13.2	17.0	33.0	38.7	50.0	61.3	23828	24604	.25					SUB-A
15-22-36-25W4M	SC-M	172.1	172.4	CORE	4.8	15.6		88.8												INSF
15-22-36-25W4M	SC-M	172.8	173.1	CORE	6.7	23.1		31.1	26.1		42.8		20159		.33					INSF
15-22-36-25W4M	SC-M	173.1	173.4	CORE	7.2	20.8	13.6	10.3	31.1	34.0	58.6	66.0	26889	25705	.34	69.55	3.95	1.15	14.72	SUB-A
15-22-36-25W4M	SC-M	173.4	173.7	CORE	6.6	17.6	12.3	19.5	30.9	37.1	49.6	62.9	24486	26351	.46					SUB-A
15-22-36-25W4M	SC-M	173.4	173.7	CORE			15.7	18.4	32.4	38.5	49.2	61.5	25028	25351	.40	62.20	3.80			SUB-A
15-22-36-25W4M	SC-M	173.7	174.0	CORE	5.5	19.2	14.6	69.3	15.5		15.2		8320		.22					INSF
2-28-36-26W4M	SC-M	240.8	248.1	CUTT	5.9			28.1	29.3		42.6		20904		.31					INSF
2-28-36-26W4M	SC-M	240.8	248.1	CUTT			14.9	14.2	31.0	35.2	54.8	64.8	25563	25025	.40	65.50	4.00			SUB-A
16- 9-37-16W4M	HC-F	114.3	115.8	CUTT	9.3		20.3	36.2	33.3		30.5		17378		1.00					INSF
4-26-37-17W4M	HC-F	83.8	86.2	CUTT	10.0		19.0	14.2	42.4	48.5	43.4	51.5	23865	22067	1.82					SUB-C
4-26-37-17W4M	HC-F	121.9	121.9	CUTT	10.2		18.9	17.4	44.4	52.8	38.2	47.2	22988	22009	1.34					SUB-C
4-26-37-17W4M	HC-F	121.9	121.9	CUTT			23.4	15.6	37.7	43.8	46.7	56.2	24004	21108	.50					SUB-C
1-28-37-18W4M	HC-F	170.7	170.7	CUTT	9.8		20.0	16.2	41.7	48.9	42.1	51.1	23983	22306	1.11					SUB-B
2- 5-37-21W4M	SC-M	65.0	68.9	CUTT	4.1			17.0	37.7		45.3		24169		.35					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
2- 5-37-21W4M	SC-M	67.0	67.0	CORE	3.8			15.3	36.4		48.3		25244		.75	63.70	4.04	.88	15.39	INSF
2- 5-37-21W4M	SC-M	67.6	67.6	CORE	3.6			13.3	40.6		46.1		25005		.44	66.00	3.49	1.05	15.76	INSF
2- 5-37-21W4M	SC-M	68.2	68.2	CORE	4.0			7.0	41.9		51.1		26996		.46	68.76	4.27	1.01	18.57	INSF
2- 5-37-21W4M	SC-M	68.5	68.5	CORE	3.9			11.1	36.3		52.6		26058		.26	66.92	4.00	.95	16.76	INSF
2- 5-37-21W4M	SC-M	68.9	68.9	CORE	4.4			7.2	40.3		52.5		27135		.46	69.74	4.38	.94	17.23	INSF
2- 5-37-21W4M	SC-M	80.0	82.0	CUTT	3.8			34.3	32.8		32.9		19083		.59					INSF
2- 5-37-21W4M	SC-M	80.3	80.3	CORE	3.5			36.6	34.4		29.0		18450		.53	46.95	3.40	.69	11.88	INSF
2- 5-37-21W4M	SC-M	81.4	81.4	CORE	4.2			9.1	42.3		48.6		27086		.50	68.64	4.83	1.13	15.79	INSF
2- 5-37-21W4M	HC-F	137.0	139.0	CUTT	3.5			15.8	39.2		45.0		24551		.37	61.68	4.24	1.04	16.92	INSF
2- 5-37-21W4M	HC-F	137.1	137.1	CORE	3.9			11.6	41.9		46.5		26281		.35	66.07	4.46	1.31	16.27	INSF
2- 5-37-21W4M	HC-F	147.2	147.2	CORE	3.9			8.1	36.5		55.4		27072		.44	68.64	4.49	1.25	17.08	INSF
2- 5-37-21W4M	HC-F	150.6	150.6	CORE	6.0			7.2	41.0		51.8		27544		.45	70.26	4.73	1.48	15.83	INSF
2- 5-37-21W4M	HC-F	151.0	152.0	CUTT	4.6			14.4	35.1		50.5		25312		.41	63.52	4.09	1.14	16.51	INSF
8-22-37-24W4M	SC-M	68.9	68.9	CUTT	3.7			24.7	32.9		42.4		21992		.53					INSF
8-22-37-24W4M	SC-M	70.0	72.9	CUTT	4.0			14.2	37.5		48.3		25060		.34					INSF
8-22-37-24W4M	HC-F	141.0	141.0	CUTT	3.9			31.4	31.1		37.5		19736		.48					INSF
8-22-37-24W4M	HC-F	157.0	159.0	CUTT	3.7			21.4	36.4		42.2		23448		.37	58.62	3.91	1.21	12.43	INSF
8-22-37-24W4M	HC-F	160.0	160.0	CUTT	3.1			35.1	30.7		34.2		18657		.38					INSF
4-13-37-27W4M	SC-M	227.1	229.2	CUTT	7.4			18.4	32.5		49.1		24374		.38					INSF
16-14-37-27W4M	SC-M	198.0	199.0	CUTT	3.0			15.6	33.6		50.8		25372		1.52					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-14-37-27W4M	SC-M	214.0	218.0	CUTT	2.4			19.1	35.1		45.8		24290		.31					INSF
16-14-37-27W4M	HC-F	300.0	302.0	CUTT	2.2			26.9	33.7		39.4		22409		.52	55.13	3.90	.98	12.58	INSF
16-14-37-27W4M	HC-F	319.0	320.0	CUTT	3.4			23.4	37.0		39.6		23414		.39	58.13	3.82	1.07	13.17	INSF
16-21-38-16W4M	HC-F	86.8	89.3	CUTT	9.4		20.4	24.5	34.4	44.0	41.1	56.0	21188	21364	.93					SUB-C
13-21-38-17W4M	HC-F	103.9	104.0	CORE	5.7	12.2		94.1	3.1		2.7				.21					INSF
13-21-38-17W4M	HC-F	104.0	104.2	CORE	8.4	15.1	15.0	66.7	14.1		19.2		7359		.29					INSF
13-21-38-17W4M	HC-F	104.2	104.5	CORE	17.1	26.1	22.6	17.3	28.9	33.7	53.9	66.3	24451	22118	.46					SUB-B
13-21-38-17W4M	HC-F	104.5	104.8	CORE	15.7	26.7	20.6	10.6	32.5	35.6	57.0	64.4	26112	22799	.51					SUB-B
13-21-38-17W4M	HC-F	104.5	104.8	CORE			23.3	17.1	34.7	40.8	48.2	59.2	23725	21197	.40					SUB-C
13-21-38-17W4M	HC-F	104.8	105.1	CORE	13.9	24.5	22.5	11.9	32.1	35.7	56.0	64.3	26054	22418	.44					SUB-B
13-21-38-17W4M	HC-F	104.8	105.1	CORE			22.8	14.9							.40	63.40	4.00			INSF
13-21-38-17W4M	HC-F	105.1	105.3	CORE	6.8	16.9	16.4	83.8	8.3		8.0				.15					INSF
13-21-38-17W4M	HC-F	106.5	106.6	CORE	6.5	18.8		89.9	10.1						.12					INSF
13-21-38-17W4M	HC-F	106.6	106.9	CORE	16.1	25.6	22.2	5.4	32.8	34.3	61.8	65.7	27354	22299	.56					SUB-B
13-21-38-17W4M	HC-F	106.9	107.2	CORE	14.5	24.2	23.8	22.9	27.2	33.5	50.0	66.5	22713	21313	.61					SUB-C
14-23-38-18W4M	HC-F	138.7	138.7	CUTT	8.7		17.7	36.7	34.2		29.1		17989		.71					INSF
1-33-38-23W4M	SC-M	31.0	32.9	CUTT	4.8			10.5	36.3		53.2		26086		.44					INSF
1-33-38-23W4M	SC-M	31.0	39.0	CUTT	4.2			16.4	34.3		49.3		24579		.53					INSF
1-33-38-23W4M	SC-M	33.9	36.0	CUTT	4.3			13.7	37.0		49.3		25309		.44					INSF
1-33-38-23W4M	SC-M	36.0	38.9	CUTT	3.8			21.6	36.2		42.2		22965		.45	58.24	3.76	.87	15.06	INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
3-28-38-24W4M	SC-M	59.4	59.4	CORE	4.5			18.2	38.6		43.2		23944		.55	62.15	3.50	.94	14.63	INSF
3-28-38-24W4M	SC-M	60.3	60.3	CORE	4.0			10.6	42.4		47.0		26640		.79	67.58	4.52	1.24	15.23	INSF
3-28-38-24W4M	SC-M	89.6	89.6	CORE	3.8			30.1	33.7		36.2		19634		.56	52.38	3.13	.79	13.02	INSF
3-28-38-24W4M	SC-M	90.0	93.9	CUTT	4.3			16.4	35.3		48.3		24535		.50					INSF
3-28-38-24W4M	SC-M	90.5	90.5	CORE	4.0			8.7	36.8		54.5		26702		.38	69.13	3.94	1.08	16.74	INSF
3-28-38-24W4M	SC-M	91.4	91.4	CORE	3.9			23.0	34.1		42.9		22497		.42	59.07	3.22	.76	13.57	INSF
3-28-38-24W4M	SC-M	94.5	94.5	CORE	2.1			71.0	17.3		11.7		9437		.32	19.46	1.84	.47	6.90	INSF
3-28-38-24W4M	SC-M	96.0	98.9	CUTT	4.0			20.2	36.6		43.2		23565		.61					INSF
13-23-38-25W4M	SC-M	123.7	126.5	CUTT	8.1			18.5	31.7		49.8		24167		.32					INSF
14-10-38-26W4M	SC-M	250.0	253.0	CUTT	6.0			15.1	36.2		48.7		25465		.27					INSF
15-14-38-27W4M	SC-M	207.3	213.4	CUTT	6.6		12.7	18.8	30.3	35.8	50.9	64.2	23509	24974	1.41					SUB-A
16-22-39-16W4M	HC-F	32.0	33.5	CUTT	8.5		19.7	25.5	34.4		40.1		20222		1.14					INSF
1-21-39-17W4M	HC-F	144.8	144.8	CUTT	7.1		19.1	44.0	24.5		31.5		15140		.56					INSF
13-22-39-18W4M	HC-F	132.6	134.1	CUTT	9.5		19.6	26.4	35.9		37.7		20641		.96					INSF
13-22-39-18W4M	HC-F	157.0	158.5	CUTT	9.5		21.8	34.5	29.3		36.1		18561		.93					INSF
14-10-39-23W4M	SC-M	40.0	41.9	CUTT	4.1			15.0	37.1		47.9		25291		.73					INSF
14-10-39-23W4M	HC-F	63.9	63.9	CUTT	3.4			39.0	29.6		31.4		16983		.46					INSF
4-29-39-24W4M	SC-M	89.0	92.6	CUTT	5.3			32.7	29.1		38.2		19906		.35					INSF
1-21-39-26W4M	SC-M	184.7	185.0	CORE	34.0	14.9		90.3												INSF
1-21-39-26W4M	SC-M	185.0	185.3	CORE	5.6	15.4	12.3	44.3	21.0		34.7		15877		.52					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-21-39-26W4M	SC-M	185.3	185.6	CORE	4.4	15.2	11.1	67.6	14.7		17.7		8185		.55					INSF
1-21-39-26W4M	SC-M	185.6	185.9	CORE	5.4	17.4	14.0	69.2	15.9		14.9		6904		.20					INSF
1-21-39-26W4M	SC-M	185.9	186.2	CORE	6.2	16.1	14.6	13.5	30.1	33.9	56.4	66.1	25944	25314	.45					SUB-A
1-21-39-26W4M	SC-M	186.2	186.5	CORE	6.7	16.5	14.3	9.4	33.4	36.3	57.2	63.7	27256	25588	.30	69.64	4.24	.81	15.56	SUB-A
1-21-39-26W4M	SC-M	186.5	186.8	CORE	6.5	17.9	13.8	9.2	33.5	36.3	57.3	63.7	27405	25842	.30					SUB-A
1-21-39-26W4M	SC-M	186.5	186.8	CORE			16.1	9.7	33.0	36.0	57.3	64.0	27447	25249	.20	69.80	4.00			SUB-A
1-21-39-26W4M	SC-M	186.8	187.1	CORE	6.2	18.3	12.3	23.3	32.6	41.0	44.1	59.0	22820	25686	.23					SUB-A
1-21-39-26W4M	SC-M	187.1	187.5	CORE	6.7	16.2	13.1	17.2	29.9	35.0	52.9	65.0	25079	25993	.32					SUB-A
1-21-39-26W4M	SC-M	187.5	187.8	CORE	3.9	15.3		83.2												INSF
1-21-39-26W4M	SC-M	187.8	188.1	CORE	7.2	23.7		91.9												INSF
1-21-39-26W4M	SC-M	188.1	188.4	CORE	6.1	18.2	11.9	58.1	17.9		24.0		11272		.19					INSF
1-21-39-26W4M	SC-M	188.4	188.7	CORE	7.0	20.0	16.7	46.8	29.0		24.2		14442		.25					INSF
1-21-39-26W4M	SC-M	188.7	189.0	CORE	6.1	15.6	12.7	16.5	30.0	34.8	53.5	65.2	24942	25793	.34					SUB-A
1-21-39-26W4M	SC-M	189.0	189.3	CORE	6.9	16.2	13.4	20.1	33.4	40.6	46.5	59.4	23951	25546	.25					SUB-A
1-21-39-26W4M	SC-M	189.3	189.6	CORE	6.4	20.5	16.7	35.5	24.1		40.4		18831		.19					INSF
1-21-39-26W4M	SC-M	189.6	189.9	CORE	7.0	22.0	14.1	31.6	29.1		39.3		20129		.22					INSF
1-21-39-26W4M	SC-M	189.9	190.2	CORE	3.8	13.3		83.5												INSF
13-23-40-16W4M	HC-F	28.9	30.4	CUTT	8.5		20.2	25.7	34.3		40.0		21113		.90					INSF
3-27-40-17W4M	HC-F	22.8	22.8	CUTT	9.2		20.3	11.8	37.4	41.6	50.8	58.4	24756	21971	1.05					SUB-C
3-27-40-17W4M	HC-F	97.5	102.1	CUTT	7.1		17.4	45.4	28.1		26.5		14640		1.05					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-22-40-18W4M	HC-F	169.2	169.2	CUTT	6.7		16.6	27.9	32.6		36.4		19876		1.23					INSF
1-16-40-23W4M	SC-M	72.0	72.9	CUTT	3.9			15.0	40.6		44.4		25072		.45					INSF
1-16-40-23W4M	HC-F	175.0	176.0	CUTT	3.9			9.5	38.9		51.6		26047		.63					INSF
2- 4-40-24W4M	SC-M	53.9	53.9	CUTT	4.3			16.2	37.4		46.4		24867		1.70	62.74	4.05	.96	14.40	INSF
2- 4-40-24W4M	SC-M	90.0	93.0	CUTT	3.8			12.2	36.6		51.2		25539		.40					INSF
2- 4-40-24W4M	SC-M	95.0	95.0	CUTT	3.8			15.5	37.9		46.6		24774		.38					INSF
2- 4-40-24W4M	SC-M	97.0	97.0	CUTT	3.4			23.4	32.2		44.4		21909		.62					INSF
5-16-40-25W4M	SC-M	181.4	181.4	CUTT	5.5			23.3	30.4		46.3		22369		.32					INSF
8-27-40-25W4M	SC-M	144.0	144.0	CUTT	4.1			11.6	34.6		53.8		26500		.54					INSF
8-27-40-25W4M	SC-M	149.0	149.0	CUTT	3.7			15.0	37.9		47.1		25737		.40					INSF
15-21-40-26W4M	SC-M	157.0	164.6	CUTT	4.8		11.7	26.7	29.1		44.2		22234		.36					INSF
15-21-40-26W4M	SC-M	157.0	164.6	CUTT			13.9	16.7	30.3	35.3	53.0	64.7	25307	25800	.40	63.20	3.80			SUB-A
1-29-40-27W4M	SC-M	251.5	259.1	CUTT	4.2		9.9	24.7	30.9	39.4	44.4	60.6	23207	27538	.38					HVB-C
1-28-41-17W4M	HC-F	82.3	82.3	CUTT	9.0		20.2	14.3	38.3	43.7	47.4	56.3	24190	22011	1.40					SUB-C
13-15-41-18W4M	HC-F	84.0	84.2	CORE	3.6	14.6	7.4	89.7	7.6		2.7				.06					INSF
13-15-41-18W4M	HC-F	84.2	84.5	CORE	12.3	23.5	20.6	21.5	40.7	50.7	37.8	49.3	23465	22851	.44					SUB-B
13-15-41-18W4M	HC-F	84.6	84.8	CORE	11.5	23.9	21.3	44.7	27.3		28.0		15863		.20					INSF
13-15-41-18W4M	HC-F	84.8	85.1	CORE	12.5	23.8	19.8	5.3	41.5	43.5	53.2	56.5	28084	23604	.51					SUB-B
13-15-41-18W4M	HC-F	84.8	85.1	CORE			22.6	6.3	39.5	41.8	54.2	58.2	27237	22253	.30					SUB-B
13-15-41-18W4M	HC-F	85.1	85.4	CORE	12.2	24.9	20.5	13.3	39.7	45.1	47.0	54.9	25672	23032	.21					SUB-B

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-22-40-18W4M	HC-F	169.2	169.2	CUTT	6.7		16.6	27.9	32.6		36.4		19876		1.23					INSF
1-16-40-23W4M	SC-M	72.0	72.9	CUTT	3.9			15.0	40.6		44.4		25072		.45					INSF
1-16-40-23W4M	HC-F	175.0	176.0	CUTT	3.9			9.5	38.9		51.6		26047		.63					INSF
2- 4-40-24W4M	SC-M	53.9	53.9	CUTT	4.3			16.2	37.4		46.4		24867		1.70	62.74	4.05	.96	14.40	INSF
2- 4-40-24W4M	SC-M	90.0	93.0	CUTT	3.8			12.2	36.6		51.2		25539		.40					INSF
2- 4-40-24W4M	SC-M	95.0	95.0	CUTT	3.8			15.5	37.9		46.6		24774		.38					INSF
2- 4-40-24W4M	SC-M	97.0	97.0	CUTT	3.4			23.4	32.2		44.4		21909		.62					INSF
5-16-40-25W4M	SC-M	181.4	181.4	CUTT	5.5			23.3	30.4		46.3		22369		.32					INSF
8-27-40-25W4M	SC-M	144.0	144.0	CUTT	4.1			11.6	34.6		53.8		26500		.54					INSF
8-27-40-25W4M	SC-M	149.0	149.0	CUTT	3.7			15.0	37.9		47.1		25737		.40					INSF
15-21-40-26W4M	SC-M	157.0	164.6	CUTT	4.8		11.7	26.7	29.1		44.2		22234		.36					INSF
15-21-40-26W4M	SC-M	157.0	164.6	CUTT			13.9	16.7	30.3	35.3	53.0	64.7	25307	25800	.40	63.20	3.80			SUB-A
1-29-40-27W4M	SC-M	251.5	259.1	CUTT	4.2		9.9	24.7	30.9	39.4	44.4	60.6	23207	27538	.38					HVB-C
1-28-41-17W4M	HC-F	82.3	82.3	CUTT	9.0		20.2	14.3	38.3	43.7	47.4	56.3	24190	22011	1.40					SUB-C
13-15-41-18W4M	HC-F	84.0	84.2	CORE	3.6	14.6	7.4	89.7	7.6		2.7				.06					INSF
13-15-41-18W4M	HC-F	84.2	84.5	CORE	12.3	23.5	20.6	21.5	40.7	50.7	37.8	49.3	23465	22851	.44					SUB-B
13-15-41-18W4M	HC-F	84.6	84.8	CORE	11.5	23.9	21.3	44.7	27.3		28.0		15863		.20					INSF
13-15-41-18W4M	HC-F	84.8	85.1	CORE	12.5	23.8	19.8	5.3	41.5	43.5	53.2	56.5	28084	23604	.51					SUB-B
13-15-41-18W4M	HC-F	84.8	85.1	CORE			22.6	6.3	39.5	41.8	54.2	58.2	27237	22253	.30					SUB-B
13-15-41-18W4M	HC-F	85.1	85.4	CORE	12.2	24.9	20.5	13.3	39.7	45.1	47.0	54.9	25672	23032	.21					SUB-B

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-15-41-18W4M	HC-F	85.1	85.4	CORE			23.5	12.0							.40	73.90	4.60			INSF
13-15-41-18W4M	HC-F	85.3	88.4	CUTT	8.8		18.4	29.1	30.4		40.4		19487		.64					INSF
13-15-41-18W4M	HC-F	85.4	85.8	CORE	10.5	18.9	16.1	38.5	28.6		32.9		17980		.31					INSF
13-15-41-18W4M	HC-F	86.0	86.4	CORE	13.0	25.7	21.4	7.6	42.2	45.3	50.2	54.7	27631	23218	.39					SUB-B
13-15-41-18W4M	HC-F	86.4	86.7	CORE	11.2	26.5	19.0	51.4	26.2		22.4		13572		.20					INSF
13-15-41-18W4M	HC-F	86.7	87.0	CORE	11.9	28.6	20.7	31.8	33.8		34.4		20034		.32					INSF
13-15-41-18W4M	HC-F	87.0	87.3	CORE	14.0	26.7	20.1	8.7	38.4	41.6	52.9	58.4	28063	24235	.42					SUB-B
13-15-41-18W4M	HC-F	87.3	87.6	CORE	13.0	23.1	21.8	17.1	37.8	44.7	45.1	55.3	25128	22960	.36					SUB-B
13-15-41-18W4M	HC-F	87.6	88.0	CORE	14.0	24.1	19.4	10.7	37.2	41.0	52.1	59.0	27172	24160	.45					SUB-B
13-15-41-18W4M	HC-F	88.0	88.1	CORE	5.6	21.5	14.1	77.4	13.9		8.7				.19					INSF
13-14-41-23W4M	UNKN	20.0	22.9	CUTT	5.9			5.3	38.8		55.9		27242		.72					INSF
13-14-41-23W4M	HC-F	75.0	76.0	CUTT	4.2			27.2	32.6		40.2		21176		.54	52.70	3.78	.73	15.05	INSF
4-28-41-27W4M	SC-M	245.4	253.0	CUTT	5.4		11.9	19.3	31.4	37.6	49.3	62.4	24586	26547	.51					SUB-A
4-27-42-17W4M	HC-F	25.9	28.9	CUTT	9.0		19.3	22.8	37.3	46.9	39.9	53.1	21439	21590	.71					SUB-C
4-27-42-17W4M	HC-F	64.0	65.5	CUTT	8.1		19.7	26.8	35.6		37.6		20446		1.33					INSF
16-22-42-18W4M	HC-F	65.5	65.5	CUTT	8.7		20.1	23.9	36.1	46.0	40.0	54.0	21285	21418	.83					SUB-C
16-15-42-19W4M	HC-F	178.3	181.4	CUTT	8.2		18.8	24.3	34.5	44.1	41.1	55.9	21315	22002	.80					SUB-C
4-30-42-23W4M	SC-M	53.9	53.9	CUTT	4.7			14.5	35.9		49.6		25037		.64					INSF
4-30-42-23W4M	SC-M	78.9	78.9	CUTT	6.0			22.6	36.5		40.9		22955		.65					INSF
4-30-42-23W4M	HC-F	120.0	120.0	CUTT	3.9			10.1	40.6		49.3		25651		.66	66.91	4.42	1.20	16.70	INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-30-42-23W4M	HC-F	124.0	126.0	CUTT	4.3			23.2	35.3		41.5		22541		.38					INSF
4-30-42-23W4M	HC-F	132.0	132.0	CUTT	4.0			15.2	38.5		46.3		24946		.48					INSF
4-30-42-23W4M	HC-F	247.0	249.0	CUTT	3.8			24.9	33.2		41.9		21802		.56					INSF
16-10-42-25W4M	SC-M	98.9	100.0	CUTT	3.8			24.9	34.8		40.3		22134		1.70					INSF
16-10-42-25W4M	SC-M	126.0	127.0	CUTT	4.0			18.7	32.4		48.9		23969		.53					INSF
16-10-42-25W4M	HC-F	180.0	181.0	CUTT	3.8			23.1	35.0		41.9		22027		.36	56.91	3.73	.68	15.26	INSF
16-10-42-25W4M	HC-F	184.0	185.0	CUTT	4.0			25.3	33.9		40.8		21539		.31					INSF
13-21-42-25W4M	SC-M	106.7	112.8	CUTT	5.7		14.8	22.6	32.7	40.7	44.7	59.3	23521	25314	.64					SUB-A
8-29-42-26W4M	SC-M	141.7	146.3	CUTT	5.1		13.4	31.1	28.2		40.7		20706		.48					INSF
6-22-43-18W4M	HC-F	56.4	57.0	CUTT	7.6		20.4	35.5	30.5		34.0		17813		.64					INSF
6-22-43-19W4M	HC-F	175.3	175.3	CUTT	8.6		19.0	17.8	35.4	42.0	46.8	58.0	22862	21930	.36					SUB-C
5-22-43-27W4M	SC-M	138.7	141.7	CUTT	5.8		13.3	18.2	33.3	39.5	48.5	60.5	24935	26077	.74					SUB-A
13-22-44-19W4M	HC-F	57.9	57.9	CUTT	10.6		21.2	15.5	37.5	43.5	46.9	56.5	24314	22071	.55					SUB-C
13-22-44-19W4M	HC-F	70.2	70.3	CORE	4.5	21.1		91.6	6.1		2.3				.16					INSF
13-22-44-19W4M	HC-F	70.3	70.7	CORE	12.2	21.3	20.8	14.3	36.9	42.2	48.8	57.8	25284	22825	.38					SUB-B
13-22-44-19W4M	HC-F	70.3	70.7	CORE			22.7	15.4	36.1	41.8	48.5	58.3	24400	21641	.40					SUB-C
13-22-44-19W4M	HC-F	70.7	71.0	CORE	11.6	26.4	21.6	39.9	26.3		33.8		16794		.35					INSF
13-22-44-19W4M	HC-F	71.0	71.3	CORE	13.2	25.8	22.6	21.9	37.0	46.1	41.1	53.9	22702	21509	.44					SUB-C
13-22-44-19W4M	HC-F	71.3	71.6	CORE	12.2	24.1	21.0	17.0	35.4	41.7	47.6	58.4	24656	22785	.41					SUB-B
13-22-44-19W4M	HC-F	71.6	71.7	CORE	12.6	23.5	22.0	7.5	37.4	39.9	55.1	60.1	27400	22816	.38					SUB-B

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-22-44-19W4M	HC-F	71.7	72.0	CORE	8.8	16.3	17.4	53.1	23.4		23.6		12235		.32					INSF
13-22-44-19W4M	HC-F	72.0	72.4	CORE	12.6	21.2	21.0	14.5	38.2	43.8	47.3	56.2	25144	22674	.64					SUB-B
13-22-44-19W4M	HC-F	72.4	72.7	CORE	13.4	22.7	21.9	7.2	36.6	38.9	56.2	61.1	27261	22669	.61					SUB-B
13-22-44-19W4M	HC-F	72.4	72.7	CORE			23.4	7.4							.50	66.70	4.10			INSF
13-22-44-19W4M	HC-F	73.1	74.0	CUTT	10.4		19.9	24.9	34.6	44.4	40.5	55.6	21404	21848	.78					SUB-C
13-22-44-19W4M	HC-F	117.4	117.7	CORE	12.0	22.4	19.7	19.7	34.5	41.7	45.9	58.3	23120	22385	.41					SUB-B
13-22-44-19W4M	HC-F	117.7	118.0	CORE	12.7	19.0	21.0	11.2	38.9	43.2	49.9	56.8	26514	23162	.30					SUB-B
13-22-44-19W4M	HC-F	118.0	118.3	CORE	11.8	19.6	20.5	13.0	38.0	42.9	49.0	57.1	25723	23025	.48					SUB-B
13-22-44-19W4M	HC-F	118.3	118.6	CORE	12.8	21.0	22.8	9.5	38.1	41.5	52.5	58.5	26940	22576	.39					SUB-B
13-22-44-19W4M	HC-F	118.6	118.9	CORE	12.5	21.2	22.2	6.6	40.1	42.5	53.4	57.5	27440	22595	.34					SUB-B
13-22-44-19W4M	HC-F	118.9	119.2	CORE	13.4	22.3	22.7	6.6	38.4	40.7	55.0	59.3	27489	22488	.31					SUB-B
13-22-44-19W4M	HC-F	119.2	119.5	CORE	12.9	21.3	20.9	14.1	33.6	38.3	52.2	61.7	24918	22416	.18					SUB-B
13-22-44-19W4M	HC-F	119.5	119.8	CORE	14.0	23.4	21.4	6.0	36.1	38.1	57.9	62.0	27449	22739	.41					SUB-B
13-22-44-19W4M	HC-F	119.8	120.1	CORE	13.2	22.2	21.8	6.0	39.0	41.2	55.0	58.8	27435	22597	.33					SUB-B
13-22-44-19W4M	HC-F	120.1	120.4	CORE	13.1	22.7	21.0	6.0	39.1	41.9	54.3	58.1	27626	23002	.30					SUB-B
13-22-44-19W4M	HC-F	120.4	120.7	CORE	9.1	15.1	15.1	33.2	26.2		40.6		19094		.22					INSF
13-22-44-19W4M	HC-F	120.7	121.0	CORE	12.0	23.0	20.0	15.3	31.9	36.6	52.8	63.4	24677	22755	.62					SUB-B
13-22-44-19W4M	HC-F	121.0	121.1	CORE	8.4	18.9	16.5	58.4	20.4		21.2		9897		.48					INSF
13-22-44-19W4M	HC-F	121.9	123.4	CUTT	9.6		19.4	25.7	32.9		41.4		21018		.52					INSF
16-22-44-20W4M	HC-F	182.9	182.9	CUTT	8.9		18.3	48.0	25.2		26.8		13993		.37					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
5-26-45-19W4M	HC-F	62.5	67.0	CUTT	12.7		20.1	29.2	29.8		41.0		20673		.85					INSF
8-24-45-28W4M	SC-M	121.9	123.4	CUTT	5.5		15.2	19.7	33.9	41.0	46.4	59.0	24195	25042	.54					SUB-A
8-24-45-28W4M	SC-M	121.9	123.4	CUTT			17.0	14.7	30.3	34.5	55.0	65.5	25144	24042	.40	63.80	3.70			SUB-B
13-22-46-19W4M	HC-F	100.6	102.4	CUTT	8.5		19.7	31.6	32.4		36.0		18706		.59					INSF
13-22-46-19W4M	HC-F	108.2	108.2	CUTT	10.5		18.8	26.3	35.2		38.5		21420		.83					INSF
16-16-46-20W4M	HC-F	105.1	105.1	CUTT	10.8		20.2	35.3	47.7		17.1		18164		.73					INSF
16-16-46-20W4M	HC-F	137.1	141.7	CUTT	12.8		19.8	22.9	38.7	48.8	38.4	51.2	22095	22102	.87					SUB-B
4-27-46-21W4M	HC-F	114.3	115.8	CUTT	9.0		19.5	30.9	31.4		37.6		19452		.48					INSF
4-27-46-21W4M	HC-F	152.4	152.4	CUTT	9.5		17.8	26.8	33.3		39.9		21569		.62					INSF
5-23-46-22W4M	HC-F	100.6	102.1	CUTT	8.7		18.6	25.8	32.2		42.0		22137		.51					INSF
1-18-46-27W4M	SC-M	135.6	137.1	CUTT	5.4		13.4	20.5	32.5	39.5	47.0	60.6	24258	26012	.82					SUB-A
1-18-46-27W4M	SC-M	181.4	182.9	CUTT	5.0		11.2	35.0	28.9		36.1		18927		.26					INSF
4-28-47-20W4M	HC-F	74.8	75.0	CORE	2.4	11.4		88.8	10.5		.7				.16					INSF
4-28-47-20W4M	HC-F	75.0	75.3	CORE	11.6	20.1	22.0	7.1	40.8	43.6	52.1	56.4	27140	22523	.09					SUB-B
4-28-47-20W4M	HC-F	75.3	75.6	CORE	11.7	19.7	22.1	10.5	41.4	45.8	48.1	54.2	25884	22120	.24					SUB-B
4-28-47-20W4M	HC-F	75.6	75.9	CORE	10.7	25.7	23.1	70.6	21.0		8.4		5627		.18					INSF
4-28-47-20W4M	HC-F	75.9	76.2	CORE	8.9	18.3	19.4	27.6	34.9		37.5		20548		.48					INSF
4-28-47-20W4M	HC-F	76.2	76.5	CORE	9.8	17.6	20.7	21.9	36.2	45.1	41.9	54.9	21985	21457	.40					SUB-C
4-28-47-20W4M	HC-F	76.7	76.8	CORE	4.1	13.1	13.9	76.4	17.2		6.4		4803		.30					INSF
4-28-47-20W4M	HC-F	77.2	77.4	CORE	3.8	15.7	10.4	76.4	18.9		4.7		4208		.06					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-28-47-20W4M	HC-F	77.4	77.7	CORE	11.2	19.3	19.8	14.0	37.3	42.5	48.7	57.5	25325	23116	.38					SUB-B
4-28-47-20W4M	HC-F	77.7	77.8	CORE	3.1	12.1		82.5	13.1		4.4		3289							INSF
4-28-47-20W4M	HC-F	78.4	78.6	CORE	2.4	14.1		92.4	7.6						.03					INSF
4-28-47-20W4M	HC-F	78.6	78.9	CORE	10.2	18.2	20.3	26.9	33.5		39.6		20583		.30					INSF
4-28-47-20W4M	HC-F	78.9	79.1	CORE	2.4	16.8		87.7	10.5		1.8				.09					INSF
4-28-47-20W4M	HC-F	86.8	88.4	CUTT	11.0		23.9	30.3	36.6		33.2		18822		1.00					INSF
4-28-47-20W4M	HC-F	114.8	115.0	CORE	4.9	13.2		93.6	6.3		.1				.27					INSF
4-28-47-20W4M	HC-F	115.0	115.3	CORE	10.7	19.7	21.1	8.1	39.9	42.9	52.1	57.1	26672	22597	.53					SUB-B
4-28-47-20W4M	HC-F	115.3	115.6	CORE	11.8	21.7	21.4	4.8	40.2	42.0	55.0	58.1	28042	22976	.25					SUB-B
4-28-47-20W4M	HC-F	115.6	115.7	CORE	10.3	20.5	16.7	22.7	33.3	41.6	44.0	58.4	22767	23828	.59					SUB-B
4-28-47-20W4M	HC-F	115.7	116.0	CORE	7.1	13.5		77.6	12.3		10.1				.41					INSF
4-28-47-20W4M	HC-F	116.0	116.3	CORE	11.6	21.4	20.7	23.3	34.9	44.0	41.8	56.0	22383	22181	.71					SUB-B
4-28-47-20W4M	HC-F	116.3	116.6	CORE	12.8	21.6	19.9	12.5	41.5	46.8	46.0	53.2	25474	22872	.47					SUB-B
4-28-47-20W4M	HC-F	116.6	116.9	CORE	12.9	21.4	20.6	7.6	44.4	47.7	48.0	52.3	26633	22618	.41					SUB-B
4-28-47-20W4M	HC-F	116.9	117.2	CORE	4.9	8.0	7.7	67.3	14.9		17.8		8239		.25					INSF
4-28-47-20W4M	HC-F	117.2	117.5	CORE	10.3	15.7	15.9	34.1	27.5		38.4		18901		.21					INSF
4-28-47-20W4M	HC-F	119.0	119.2	CORE	8.4	19.0	14.0	69.9	21.3		8.8		6852		.16					INSF
4-28-47-20W4M	HC-F	119.2	119.5	CORE	13.1	20.2	18.4	16.6	39.9	46.8	43.6	53.2	25328	24207	.74					SUB-B
4-28-47-20W4M	HC-F	119.5	119.8	CORE	14.5	20.0	20.7	33.0	34.5		32.6		20101		.46					INSF
4-28-47-20W4M	HC-F	119.8	120.1	CORE	13.2	21.0	18.7	18.0	39.4	47.1	42.6	52.9	24879	24028	.18					SUB-B

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-28-47-20W4M	HC-F	120.1	120.8	CORE	12.5	17.3	16.9	29.8	31.4		38.8		21062		.24					INSF
4-28-47-20W4M	HC-F	120.8	121.0	CORE	4.8	14.9		93.0	7.0						.07					INSF
16-16-47-21W4M	HC-F	117.3	118.9	CUTT	6.8		18.1	44.5	33.0		22.4		14775		.65					INSF
16-16-47-21W4M	HC-F	166.1	166.1	CUTT	8.6		18.5	21.2	34.4	42.3	44.4	57.7	22804	22846	.70					SUB-B
16-16-48-19W4M	HC-F	42.6	42.6	CUTT	10.7		20.5	28.9	42.8		28.2		19822		.73					INSF
16-16-48-19W4M	HC-F	53.3	53.3	CUTT	8.5		20.5	25.0	35.5	45.8	39.5	54.2	20953	21201	.55					SUB-C
16-16-48-19W4M	HC-F	60.9	60.9	CUTT	7.0		20.4	49.6	28.5		21.9		13026		.69					INSF
16-16-48-19W4M	HO-F	77.7	82.3	CUTT	10.9		20.8	29.4	42.1		28.5		20094		.70					INSF
4-27-48-20W4M	HC-F	62.5	62.5	CUTT	9.8		21.1	36.1	33.2		30.7		17787		.33					INSF
4-27-48-20W4M	HC-F	114.3	114.3	CUTT	8.3		21.2	30.1	33.9		36.0		20036		.53					INSF
4-27-48-21W4M	HC-F	163.1	163.1	CUTT	10.7		17.2	33.2	31.1		35.8		19248		.26					INSF
13-14-49-20W4M	HC-F	103.6	106.7	CUTT	8.7		18.7	40.1	32.0		27.9		15849		1.81					INSF
16-21-49-21W4M	HC-F	109.7	112.8	CUTT	10.3		21.9	18.2	39.5	47.2	42.3	52.8	22967	21190	.65					SUB-C
16-21-49-21W4M	HC-F	111.2	112.8	CUTT			24.5	14.9	38.2	44.1	46.9	55.9	24167	20767	.30					SUB-C
16-21-49-21W4M	HC-F	125.0	125.0	CUTT	11.3		18.7	31.8	33.8		34.4		19517		.73					INSF
16-21-49-21W4M	HC-F	147.8	150.9	CUTT	11.1		20.4	32.5	33.5		34.0		18573		.44					INSF
1-28-49-22W4M	HC-F	167.6	169.2	CUTT	9.8		20.6	11.6	36.0	39.9	52.5	60.1	25572	22544	.90					SUB-B
1-28-49-22W4M	HC-F	185.9	187.5	CUTT	10.6		20.1	14.9	33.7	38.5	51.4	61.5	24965	22904	.89					SUB-B
1-28-49-22W4M	HC-F	193.5	195.1	CUTT	12.4		19.1	24.7	32.7	41.7	42.7	58.3	22727	23441	.85					SUB-B
4-18-50-20W4M	HC-F	128.0	128.0	CUTT	11.1		20.4	46.4	33.8		19.8		13705		.31					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-21-50-22W4M	HC-F	126.8	127.1	CORE	1.4	19.1		85.1	14.9						.27					INSF
16-21-50-22W4M	HC-F	127.1	127.4	CORE	13.5	26.6	22.1	18.8	31.7	37.9	49.5	62.1	24267	22453	.30					SUB-B
16-21-50-22W4M	HC-F	127.8	128.1	CORE	6.7	23.2		90.8	6.5		2.7				.12					INSF
16-21-50-22W4M	HC-F	128.1	128.3	CORE	13.8	33.5	21.4	18.5	35.5	42.4	46.1	57.6	23979	22355	.34					SUB-B
16-21-50-22W4M	HC-F	135.4	135.6	CORE	8.7	26.4		87.5	12.6						.33					INSF
16-21-50-22W4M	HC-F	135.6	135.9	CORE	13.8	27.0	20.4	26.9	37.5		35.6		21978		.42					INSF
16-21-50-22W4M	HC-F	135.9	136.2	CORE	16.3	32.5	22.9	4.7	40.8	42.5	54.5	57.5	28849	23155	.44					SUB-B
16-21-50-22W4M	HC-F	136.2	136.4	CORE	14.9	31.3	21.9	8.3	38.6	41.5	53.2	58.5	27672	23234	.56					SUB-B
16-21-50-22W4M	HC-F	159.2	160.8	CORE	7.4	20.3		93.5	5.7		.8									INSF
16-21-50-22W4M	HC-F	160.9	161.2	CORE	18.1	27.4	20.5	13.7	39.6	45.3	46.6	54.8	27016	24349	.09					SUB-B
16-21-50-22W4M	HC-F	161.1	161.4	CORE	18.6	27.3	21.8	10.7	38.3	42.3	51.1	57.7	27242	23407	.22					SUB-B
16-21-50-22W4M	HC-F	161.4	161.7	CORE	19.0	30.3	21.3	11.1	37.9	42.0	51.0	58.0	27638	24014	.30					SUB-B
16-21-50-22W4M	HC-F	161.7	162.1	CORE	15.5	24.6	18.2	40.3	24.7		35.1		19166		.12					INSF
16-21-50-22W4M	HC-F	162.6	162.9	CORE	18.8	29.5	22.1	26.6	31.7		41.7		23297		.17					INSF
16-21-50-22W4M	HC-F	162.9	163.2	CORE	19.5	30.4	21.7	7.2	38.2	40.8	54.6	59.2	28659	23893	.30					SUB-B
16-21-50-22W4M	HC-F	163.1	164.6	CUTT	11.3		20.7	28.2	33.1		38.7		20564		.39					INSF
16-21-50-22W4M	HC-F	163.2	163.5	CORE	18.0	27.7	20.8	24.0	33.6	42.7	42.4	57.3	24904	24821	.37					SUB-A
16-21-50-22W4M	HC-F	163.5	163.7	CORE	11.2	24.9	14.8	72.1	15.1		12.9		7204		.19					INSF
4-27-50-23W4M	HC-F	153.9	153.9	CUTT	10.1		19.7	27.5	35.6		36.9		21234		.58					INSF
1-22-51-21W4M	HC-F	77.7	79.2	CUTT	9.9		20.5	33.1	37.0		29.9		19027		1.57					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-28-51-22W4M	HC-F	85.3	89.9	CUTT	12.1		18.8	35.5	37.4		27.1		18408		.85					INSF
1-28-51-22W4M	HC-F	126.5	126.5	CUTT	9.0		19.4	22.4	35.6	44.4	42.0	55.6	22237	22262	1.07					SUB-B
16- 9-51-23W4M	HC-F	106.7	108.2	CUTT	12.5		20.5	22.6	36.1	45.2	41.3	54.8	22672	22355	.96					SUB-B
16- 9-51-23W4M	HC-F	114.3	115.8	CUTT	11.9		19.6	17.2	36.8	43.4	46.0	56.6	24537	23204	.83					SUB-B
16- 9-51-23W4M	HC-F	121.9	121.9	CUTT	12.4		21.6	9.7	38.5	42.1	51.7	57.9	26354	22518	.65					SUB-B
16- 9-51-23W4M	HC-F	152.4	153.9	CUTT	12.3		20.3	12.3	36.3	40.6	51.4	59.5	26223	23381	.79					SUB-B
16-16-52-21W4M	HC-F	44.2	44.2	CUTT	9.7			25.9	43.4		30.7		20597		.76					INSF
16-16-52-21W4M	HC-F	71.6	71.6	CUTT	7.3			39.5	34.5		25.9		16736		1.26					INSF
16-16-52-21W4M	HC-F	71.6	71.6	CUTT	9.7		20.0	17.5	38.3	45.3	44.2	54.7	23281	21939	1.11					SUB-C
8-22-52-22W4M	HC-F	56.4	56.4	CUTT	12.4		21.3	25.3	30.8		43.9		21092		.61					INSF
8-22-52-22W4M	HC-F	89.9	94.5	CUTT	11.2		20.4	28.7	35.3		36.0		21155		.86					INSF
13-16-52-23W4M	HC-F	80.7	80.7	CUTT	9.9		20.2	33.3	29.8		36.9		18610		.62					INSF
1-28-53-23W4M	HC-F	27.4	27.4	CORE			21.8								.91					INSF
4-28-54-25W4M	HC-F	45.7	45.7	CUTT	10.3		22.6	21.2	35.1	43.1	43.7	56.9	22274	20939	.90					SUB-C
4-28-54-25W4M	HC-F	70.2	70.4	CORE	3.8	20.8		91.2	8.5		.2				.17					INSF
4-28-54-25W4M	HC-F	70.4	70.7	CORE	7.7	22.7	19.1	18.0	38.9	46.4	43.2	53.6	24260	23281	.36					SUB-B
4-28-54-25W4M	HC-F	70.4	70.7	CORE			22.3	19.7	36.0	43.7	44.3	56.3	23609	21976	.30					SUB-C
4-28-54-25W4M	HC-F	70.7	71.0	CORE	9.4	24.6	20.8	27.2	37.5		35.3		21562		.31					INSF
4-28-54-25W4M	HC-F	71.0	71.3	CORE	9.2	20.2	19.2	12.0	38.6	43.2	49.4	56.8	26447	23879	.36					SUB-B
4-28-54-25W4M	HC-F	71.3	71.4	CORE	6.8	23.4	16.7	28.3	31.4		40.3		21074		.29					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-28-54-25W4M	HC-F	71.4	71.6	CORE	3.8	18.7	10.9	81.0	12.9		6.2				.14					INSF
4-28-54-25W4M	HC-F	73.1	73.1	CUTT	10.8		18.9	26.1	33.9		40.0		20839		.71					INSF
4-28-54-25W4M	HC-F	80.2	80.3	CORE	4.1	16.4		90.7	7.3		2.1				.22					INSF
4-28-54-25W4M	HC-F	80.3	80.7	CORE	6.8	17.9	16.5	42.2	28.1		29.7		16794		.36					INSF
4-28-54-25W4M	HC-F	81.4	81.7	CORE	8.6	17.3	17.5	17.7	39.5	47.0	42.8	53.0	24958	24446	.43					SUB-A
4-28-54-25W4M	HC-F	81.7	82.0	CORE	7.7	21.0	19.1	14.5	39.2	45.1	46.3	54.9	25381	23514	.30					SUB-B
4-28-54-25W4M	HC-F	81.7	82.0	CORE				17.2							.30	62.80	3.80			INSF
4-28-54-25W4M	HC-F	82.0	82.1	CORE	7.8	20.9	17.6	19.0	35.9	43.3	45.1	56.8	23283	23093	.21					SUB-B
4-28-54-25W4M	HC-F	82.1	82.3	CORE	3.9	5.7		89.2	9.8		1.0				.19					INSF
4-28-54-25W4M	HC-F	138.7	140.2	CUTT	11.1		18.5	26.3	32.7		40.9		20618		.97					INSF
16- 8-54-27W4M	WP-F	185.2	185.8	CUTT	5.8			18.0	35.0		47.0		23167		.39					INSF
9-20-55-26W4M	HC-F	59.4	60.9	CUTT			24.7	11.9	40.7	45.6	47.4	54.4	25191	20997	.30					SUB-C
9-20-55-26W4M	HC-F	59.4	60.9	CUTT	8.3		19.6	20.3	33.5	40.6	46.1	59.4	22116	21597	1.30					SUB-C
16-21-55-27W4M	WP-F	63.4	64.1	CUTT	6.7			16.0	38.2		45.8		23632		.33					INSF
9-20-56-27W4M	WP-F	111.2	113.2	CUTT	6.4			9.1	38.4		52.5		25572		.29					INSF
9-16-59-22W4M	WP-F	137.0	137.8	CUTT	6.3			12.3	38.1		49.6		24430		.54					INSF
1-27-59-23W4M	WP-F	180.4	182.0	CUTT	7.2			11.0	38.8		50.2		24979		.23					INSF
2-21-60-25W4M	WP-F	90.5	91.4	CUTT	6.7			8.9	39.4		51.7		26000		.34					INSF
2-21-60-25W4M	WP-F	204.4	205.3	CUTT	6.4			13.5	37.1		49.4		24665		.34					INSF
16-21-61-22W4M	WP-F	47.2	48.0	CUTT	6.2			12.4	40.1		47.5		23897		.32					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
1-21-61-24W4M	WP-F	154.5	155.1	CUTT	6.6			16.0	37.3		46.7		23246		.51					INSF
9-17-61-26W4M	WP-F	217.0	217.6	CUTT	6.4			10.0	38.8		51.2		24851		.50					INSF
1-16-62-21W4M	WP-F	24.0	24.8	CUTT	7.3			8.8	40.5		50.7		24853		.39					INSF
13-11-43- 1W5M	SC-M	265.2	267.3	CUTT											.77					INSF
13-21-45- 1W5M	SC-M	212.8	213.1	CORE	6.5	18.1	12.8	62.9	16.0		21.1		9918		.16					INSF
13-21-45- 1W5M	SC-M	213.1	213.4	CORE		17.3	12.6	43.7	22.6		33.7		16142		.26					INSF
13-21-45- 1W5M	SC-M	213.1	213.4	CORE			14.8	41.0	22.9		36.1		17422		.30	44.90	2.70			INSF
13-21-45- 1W5M	SC-M	213.4	213.7	CORE	7.9	17.3	13.2	35.2	24.7		40.1		19462		.28					INSF
13-21-45- 1W5M	SC-M	213.7	214.0	CORE	7.7	24.6		81.6												INSF
13-21-45- 1W5M	SC-M	214.0	214.3	CORE	7.5	15.7	15.3	27.2	26.1		46.7		22078		.27					INSF
13-21-45- 1W5M	SC-M	214.3	214.6	CORE	4.8	12.6	11.4	68.0	15.7		16.3		8460		.15					INSF
13-21-45- 1W5M	SC-M	214.6	214.9	CORE	7.5	15.2	13.1	33.3	29.8		36.9		19671		.38					INSF
13-21-45- 1W5M	SC-M	214.9	215.2	CORE	8.0	19.6	13.6	44.8	25.9		29.3		16242		.38					INSF
13-21-45- 1W5M	SC-M	215.2	215.5	CORE	7.9	20.0	12.9	17.5	30.6	36.0	51.9	64.0	25298	26379	.26					SUB-A
13-21-45- 1W5M	SC-M	215.5	215.8	CORE	7.5	16.7	13.5	18.8	33.7	40.3	47.5	59.7	24586	25807	.37	61.32	4.19	.94	14.36	SUB-A
13-21-45- 1W5M	SC-M	215.8	216.1	CORE	8.4	21.0	15.0	44.6	23.5		31.9		15610		.20					INSF
13-21-45- 1W5M	SC-M	216.1	216.4	CORE	9.2	23.7	16.7	66.0	15.8		18.2		8443		.23					INSF
13-21-45- 1W5M	SC-M	216.4	216.6	CORE	7.1	15.8	14.0	22.8	29.8	37.0	47.4	63.0	23541	25695	.52					SUB-A
13-21-45- 1W5M	SC-M	216.6	216.7	CORE	7.6	25.7		85.2												INSF
13-21-45- 1W5M	SC-M	216.7	217.0	CORE	8.1	16.8	14.9	8.7	34.1	36.8	57.2	63.2	27689	25614	.23					SUB-A

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
13-21-45- 1W5M	SC-M	217.0	217.3	CORE	8.3	16.5	14.2	9.5	36.3	39.6	54.2	60.4	27435	25814	.17					SUB-A
13-21-45- 1W5M	SC-M	217.3	217.6	CORE	3.0	14.3		91.0												INSF
13-21-45- 1W5M	SC-M	250.0	250.3	CORE	3.2	8.9		92.7												INSF
13-21-45- 1W5M	SC-M	250.3	250.6	CORE	5.4	15.5		82.8												INSF
13-21-45- 1W5M	SC-M	250.6	250.9	CORE	8.4	17.1	14.2	37.2	23.6		39.2		18338		.31					INSF
13-21-45- 1W5M	SC-M	250.9	251.2	CORE	7.5	17.4	14.4	10.6	37.2	41.0	52.2	59.0	27130	25751	.31	68.67	3.91	.96	15.58	SUB-A
13-21-45- 1W5M	SC-M	251.2	251.5	CORE	6.3	15.7	12.0	45.4	22.5		32.1		16045		.34					INSF
13-21-45- 1W5M	SC-M	251.5	251.8	CORE	6.7	18.1	12.0	45.8	22.9		31.3		15531		.36					INSF
13-21-45- 1W5M	SC-M	251.8	252.1	CORE	7.6	14.2	13.6	8.9	37.1	40.2	54.0	59.8	27812	26209	.35					SUB-A
13-21-45- 1W5M	SC-M	252.1	252.2	CORE	6.7	14.0	12.7	45.8	23.2		31.0		15710		.28					INSF
13-21-45- 1W5M	SC-M	252.2	252.4	CORE	3.0	13.6		92.1												INSF
4-22-46- 1W5M	SC-M	175.3	176.8	CUTT	5.9			11.7	35.0		53.3		26747		.41					INSF
8-28-47- 1W5M	SC-M	121.9	123.4	CUTT	7.4		16.9	7.7	34.5	36.9	57.8	63.1	27584	24623	.24					SUB-A
8-28-47- 1W5M	SC-M	121.9	123.4	CUTT			17.7	8.2	32.1	34.5	59.7	65.5	27168	24116	.20	68.60	4.00			SUB-B
15-22-47- 2W5M	SC-M	164.6	170.7	CUTT	5.5		14.4	7.4	34.3	36.6	58.3	63.4	28638	26323	.43					SUB-A
15-22-47- 2W5M	SC-M	185.9	187.5	CUTT	5.2		12.5	17.2	32.3	37.9	50.5	62.1	25381	26530	.39					SUB-A
15-22-47- 2W5M	SC-M	202.7	204.2	CUTT	5.4		12.9	16.1	31.0	35.8	52.9	64.2	25865	26565	.63					SUB-A
15-22-47- 2W5M	SC-M	214.9	216.4	CUTT	5.2		13.1	18.6	31.0	36.8	50.4	63.2	25009	26342	.50					SUB-A
4-27-47- 3W5M	SC-M	224.0	225.6	CUTT	4.8			18.6	31.8		49.6		25260		.40					INSF
4-27-47- 3W5M	SC-M	234.7	236.2	CUTT	5.0		14.2	12.5	33.3	37.3	54.2	62.7	27226	26426	.35					SUB-A

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
9-17-48- 4W5M	SC-M	185.9	189.0	CUTT	4.4			48.3	20.9		30.8		15491		.24					INSF
9-17-48- 4W5M	SC-M	230.1	233.2	CUTT	5.5		13.0	10.1	32.8	35.9	57.1	64.1	27447	26388	.29					SUB-A
9-21-48- 5W5M	SC-M	197.5	199.6	CUTT	5.3		11.9	38.8	29.3		31.9		18378		.46					INSF
16-21-49- 4W5M	SC-M	155.4	160.0	CUTT	6.8		15.8	14.8	34.2	39.2	51.0	60.8	25305	24625	.33					SUB-A
14-27-49- 7W5M	SC-M	265.2	272.8	CUTT	5.7			26.4	29.1		44.5		22113		.38					INSF
9-30-50- 5W5M	SC-M	117.3	123.4	CUTT	7.4			12.2	36.8		51.0		25574		.17					INSF
9-30-50- 5W5M	SC-M	134.1	135.6	CUTT	6.1			28.1	31.0		40.9		21643		.68					INSF
9-21-50- 7W5M	SC-M	234.7	243.9	CUTT	6.7		14.2	11.7	34.3	38.2	54.0	61.8	26084	25102	.21					SUB-A
12-20-51- 5W5M	SC-M	105.1	120.4	CUTT	7.0		15.1	16.5	33.6	39.2	49.9	60.8	24116	24125	.25					SUB-B
16-23-51- 8W5M	SC-M	233.2	234.7	CUTT	5.5		14.4	25.7	29.6		44.7		21692		.26					INSF
16- 9-52- 6W5M	SC-M	134.1	140.2	CUTT	5.6		13.9	43.0	27.2		29.8		15545		.36					INSF
16- 9-52- 6W5M	SC-M	134.1	140.2	CUTT			15.2	23.2	30.7	38.4	46.1	61.6	22399	24125	.50	57.50	3.50			SUB-B
16- 8-53- 8W5M	SC-M	163.4	163.7	CORE	6.6	16.8	13.8	19.4	33.6	40.4	47.0	59.6	24825	26135	.70					SUB-A
16- 8-53- 8W5M	SC-M	163.4	163.7	CORE	4.6	12.1	10.1	77.0	12.8		10.2		4619		.27					INSF
16- 8-53- 8W5M	SC-M	163.7	164.0	CORE	4.0	12.3		81.6												INSF
16- 8-53- 8W5M	SC-M	164.0	164.3	CORE	6.2	16.3	13.9	34.1	37.5		28.4		19157		.43					INSF
16- 8-53- 8W5M	SC-M	164.3	164.6	CORE	7.0	18.7	15.1	15.3	35.4	40.9	49.3	59.1	25000	24693	.35					SUB-A
16- 8-53- 8W5M	SC-M	164.6	164.9	CORE	6.2	16.1	14.2	30.6	28.6		40.8		19876		.26					INSF
16- 8-53- 8W5M	SC-M	164.9	165.2	CORE	6.2	16.2	13.7	29.7	30.6		39.7		19813		.26					INSF
16- 8-53- 8W5M	SC-M	165.2	165.5	CORE	7.3	19.6	15.0	10.9	30.4	33.4	58.7	66.6	26714	25235	.21	70.00	3.89	.90	14.14	SUB-A

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	AR	MEQ	ASH DRY	VL-MATTER DRY	DMMF	FX-CARBON DRY	DMMF	CAL-VALUE DRY	MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16- 8-53- 8W5M	SC-M	165.5	165.8	CORE	6.3	16.4	11.7	19.0	34.7	41.7	46.3	58.3	22748	24530	.19					SUB-A
16- 8-53- 8W5M	SC-M	165.8	166.1	CORE	5.9	17.6	13.8	31.6	45.4		23.0		19417		.18					INSF
16- 8-53- 8W5M	SC-M	166.1	166.4	CORE	7.1	19.1	14.3	11.2	35.3	39.1	53.5	60.9	26021	24879	.20					SUB-A
16- 8-53- 8W5M	SC-M	166.4	166.7	CORE	6.2	18.8	14.9	22.7	31.6	39.4	45.7	60.6	23255	25009	.22					SUB-A
16- 8-53- 8W5M	SC-M	166.7	167.0	CORE	2.6	17.6		87.2												INSF
16- 8-53- 8W5M	SC-M	167.0	167.3	CORE	2.1	16.0		95.0												INSF
16-20-54- 2W5M	WP-F	48.7	49.8	CUTT	5.4			11.6	38.5		49.9		24693		.26					INSF
16-20-54- 2W5M	WP-F	171.9	173.3	CUTT	5.8			9.2	39.2		51.6		25407		.30					INSF
13-21-54- 9W5M	SC-M	179.8	185.9	CUTT	5.2			22.5					23572		.78					INSF
13-24-55- 2W5M	WP-F	180.0	181.0	CUTT	6.7			12.1	37.1		50.8		24914		.43					INSF
13-22-55- 9W5M	SC-M	100.6	101.2	CUTT	6.4		16.8	9.2	35.9	39.0	54.9	61.0	27461	24909	.34					SUB-A
13-22-55- 9W5M	SC-M	109.7	112.8	CUTT	5.3		14.1	16.7	32.5	37.8	50.8	62.2	25214	25653	1.08					SUB-A
13-15-55-12W5M	UNKN	199.0	199.0	CUTT	5.3			30.6	28.5		40.9		21734		.30					INSF
4-26-56- 2W5M	WP-F	91.7	92.3	CUTT	5.6			8.8	37.3		53.9		25223		.32					INSF
4-26-56- 2W5M	WP-F	91.7	91.9	CORE	5.4			8.9	43.7		47.4		26091		.40					INSF
4-26-56- 2W5M	WP-F	91.9	92.1	CORE	5.3			10.0	43.4		46.6		25995		.45					INSF
4-26-56- 2W5M	WP-F	92.1	92.3	CORE	3.6			73.3	19.1		7.6		6587		.11					INSF
4-26-56- 2W5M	WP-F	92.3	92.5	CORE	3.5			67.2	17.0		15.8		8411		.21					INSF
4-26-56- 2W5M	WP-F	92.5	92.6	CORE	5.6			13.8	40.4		45.8		24616		.30					INSF
4-26-56- 2W5M	WP-F	92.6	94.2	CUTT	5.8			11.4	39.2		49.4		24539		.27					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
4-26-56- 2W5M	WP-F	92.6	92.8	CORE	5.6			9.3	41.2		49.5		26184		.24	66.95	4.40	1.39	17.71	INSF
4-26-56- 2W5M	WP-F	92.8	92.9	CORE	5.8			16.9	39.3		43.8		23779		.28					INSF
4-26-56- 2W5M	WP-F	93.0	93.2	CORE	5.3			23.7	37.2		39.1		21869		.30					INSF
4-26-56- 2W5M	WP-F	93.2	93.3	CORE	5.9			24.6	37.1		38.3		21162		.30	54.02	3.74	1.10	16.19	INSF
4-26-56- 2W5M	WP-F	93.3	93.5	CORE	5.7			6.4	41.8		51.8		26942		.28					INSF
4-26-56- 2W5M	WP-F	93.5	93.6	CORE	5.9			10.4	42.4		47.2		25412		.28					INSF
4-26-56- 2W5M	WP-F	93.6	93.8	CORE	6.0			6.5	39.6		53.9		26591		.31					INSF
4-26-56- 2W5M	WP-F	93.7	93.9	CORE	6.5			6.6	41.1		52.3		26837		.19	68.90	4.56	1.50	18.27	INSF
4-26-56- 2W5M	WP-F	93.9	94.1	CORE	5.9	26.4		7.3	43.2		49.5		26668		.37					INSF
4-26-56- 2W5M	WP-F	94.1	94.2	CORE	7.0	25.5		4.7	39.3		56.0		27393		.37					INSF
4-26-56- 2W5M	WP-F	94.2	94.5	CORE	6.7	25.4		4.5	39.8		55.7		27628		.34	65.19	4.40	1.28	24.29	INSF
5-24-56- 3W5M	WP-F	105.3	106.4	CUTT	6.1			11.6	36.4		52.0		23293		.39					INSF
4-26-56-10W5M	SC-M	60.9	62.5	CUTT	4.9			32.7					20150		.96					INSF
16-21-56-11W5M	SC-M	216.6	216.7	CORE	3.2	11.5		86.9												INSF
16-21-56-11W5M	SC-M	216.7	217.0	CORE	8.0	21.3	15.2	39.1	29.1		31.8		17959		.37					INSF
16-21-56-11W5M	SC-M	217.0	217.3	CORE	6.6	23.8	13.3	51.4	20.9		27.7		13426		.29					INSF
16-21-56-11W5M	SC-M	217.3	217.6	CORE	7.3	19.7	14.9	31.0	30.0		39.0		20811		.87					INSF
16-21-56-11W5M	SC-M	217.3	217.6	CORE			16.6	27.8	29.7		42.5		21934		1.00	55.10	3.50			INSF
16-21-56-11W5M	SC-M	217.6	217.9	CORE	3.0	16.7		89.4												INSF
16-21-56-11W5M	SC-M	217.9	218.2	CORE	6.7	16.9	13.4	32.4	27.1		40.5		20292		.59					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-21-56-11W5M	SC-M	218.2	218.5	CORE	5.5	19.0		80.1												INSF
16-21-56-11W5M	SC-M	218.5	218.9	CORE	6.1	13.5	9.4	47.9	21.3		30.8		16226		.28					INSF
16-21-56-11W5M	SC-M	218.9	219.0	CORE	8.7	42.2		91.0												INSF
16-21-56-11W5M	SC-M	219.0	219.2	CORE	7.0	15.6	12.8	27.2	25.7		47.1		21916		.30					INSF
16-21-56-11W5M	SC-M	219.2	219.5	CORE	8.4	19.5	15.6	11.4	32.2	35.6	56.4	64.4	26935	25374	.28					SUB-A
16-21-56-11W5M	SC-M	219.5	219.8	CORE	8.8	19.4	15.7	9.1	40.5	44.1	50.4	55.9	27517	25295	.29	69.99	4.17	1.01	15.42	SUB-A
16-21-56-11W5M	SC-M	219.8	220.1	CORE	8.0	17.0	13.9	14.7	40.7	47.0	44.6	53.1	25800	25735	.28					SUB-A
16-21-56-11W5M	SC-M	220.1	220.4	CORE	3.3	16.3		78.8												INSF
16-21-56-11W5M	SC-M	221.6	221.7	CORE	2.2	11.2		92.1												INSF
16-21-56-11W5M	SC-M	221.7	221.9	CORE	7.5	19.5	17.7	16.1	31.4	36.2	52.5	63.8	25539	24546	1.08					SUB-A
16-21-56-11W5M	SC-M	221.9	222.2	CORE	6.8	19.6	16.2	24.5	28.5	36.0	47.0	64.0	22688	24435	.38					SUB-A
16-21-56-11W5M	SC-M	222.6	222.8	CORE	5.5	17.6	13.3	44.1	23.7		32.2		16615		1.06					INSF
16-21-56-11W5M	SC-M	222.8	223.1	CORE	2.5	11.8		93.5												INSF
16-21-56-11W5M	SC-M	223.4	223.7	CORE	4.6	14.5	11.0	64.8	16.6		18.6		8723		.27					INSF
16-21-56-11W5M	SC-M	223.7	224.0	CORE	6.8	15.3	12.9	30.8	28.0		41.2		20680		.46					INSF
16-21-56-11W5M	SC-M	224.0	224.3	CORE	5.9	16.3	12.8	58.4	21.7		19.9		10497		.21					INSF
16-21-56-11W5M	SC-M	224.3	224.6	CORE	4.4	15.2		80.0												INSF
16-21-56-11W5M	SC-M	224.6	225.0	CORE	6.7	20.5	13.1	43.3	22.4		34.3		16498		.36					INSF
16-21-56-11W5M	SC-M	225.0	225.3	CORE	7.7	17.2	14.7	21.1	29.8	36.3	49.1	63.7	23969	25386	.44					SUB-A
16-21-56-11W5M	SC-M	225.3	225.6	CORE	6.6	19.8	13.4	34.7	33.5		31.8		19499		.33					INSF

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LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-21-56-11W5M	SC-M	225.6	225.7	CORE	5.9	41.4		92.3												INSF
16-21-56-11W5M	SC-M	225.7	225.9	CORE	4.0	13.2		94.2												INSF
1- 8-56-12W5M	SC-M	257.6	260.6	CUTT	5.7			26.7	29.8		43.5		21955		.25					INSF
1- 8-56-12W5M	SC-M	257.6	260.6	CUTT			16.2	17.6	32.0	37.7	50.4	62.3	24795	24718	.30	63.10	4.00			SUB-A
13-33-56-12W5M	SC-M	178.3	179.8	CUTT	5.3			32.8	26.9		40.3		19266		.26					INSF
13-33-56-12W5M	SC-M	205.7	207.3	CUTT	6.5		13.7	14.2	34.2	39.0	51.6	61.0	26123	25991	.35					SUB-A
13-33-56-12W5M	SC-M	219.5	221.0	CUTT	6.3		13.1	27.4	28.3		44.3		21702		.31					INSF
16-21-57- 3W5M	WP-F	30.7	31.7	CUTT	7.6			8.2	40.9		50.9		24765		.44					INSF
16-21-57- 3W5M	WP-F	32.0	32.7	CUTT	6.7			15.6	39.7		44.7		23055		.95					INSF
13-14-57-11W5M	SC-M	150.9	155.4	CUTT	6.2		15.1	21.4	32.4	39.8	46.2	60.2	23402	24723	.49					SUB-A
13-21-58- 3W5M	WP-F	83.5	84.6	CUTT	6.1			6.5	40.4		53.1		26886		.28					INSF
13-21-58- 3W5M	WP-F	83.5	84.7	CUTT	6.5			9.9	39.3		50.8		25325		.21					INSF
13-21-58- 3W5M	WP-F	84.7	86.4	CUTT	5.3			18.1	39.2		42.7		23127		.31					INSF
13-21-58- 3W5M	WP-F	84.7	86.4	CUTT	5.3			6.2	42.0		51.8		26809		.26					INSF
4-26-58- 5W5M	WP-F	118.9	119.2	CUTT	6.6			9.2	39.3		51.5		26323		.29					INSF
4-26-58- 5W5M	WP-F	119.2	119.8	CUTT	6.2			17.4	37.8		44.8		23809		.35					INSF
4-26-58- 5W5M	WP-F	126.5	128.8	CUTT	6.7			13.8	35.9		50.3		24828		.32					INSF
4-27-58- 6W5M	WP-F	99.5	100.4	CUTT	6.0			12.1	36.8		51.1		25263		.30					INSF
4-27-58- 6W5M	WP-F	147.7	149.5	CUTT	5.8			11.0	38.6		50.1		25872		.35					INSF
16-20-59- 4W5M	WP-F	52.1	53.2	CUTT	5.8			17.4	36.0		46.6		23032		.22					INSF

APPENDIX 1

LOCATION	COAL ZONE	UPPER DEPTH	LOWER DEPTH	SAMP TYPE	MOISTURE AD	MOISTURE AR	MOISTURE MEQ	ASH DRY	VL-MATTER DRY	VL-MATTER DMMF	FX-CARBON DRY	FX-CARBON DMMF	CAL-VALUE DRY	CAL-VALUE MMMF	ULT-ANALYSIS (DRY) S	C	H	N	O	COAL RANK
16-20-59- 4W5M	WP-F	53.3	54.1	CUTT	6.0			9.5	38.6		51.9		25828		.36					INSF
8-20-59- 6W5M	WP-F	89.1	90.0	CUTT	6.3			6.7	39.0		54.3		27049		.29					INSF
8- 6-59-12W5M	SC-M	144.8	147.8	CUTT	6.0		15.5	22.6	30.7	38.1	46.7	61.9	23879	25428	.53					SUB-A
1-22-63- 1W5M	WP-F	14.9	15.7	CUTT	7.6			9.5	40.4		50.1		25079		.32					INSF
10-20-67-10W6M	WP-F	194.6	195.4	CUTT	3.5			15.8	33.6		50.6		27277		.39					INSF

Appendix 2

Parr Formulae

DMMFFC = [(FC – 0.15S)(100)]/[100 – (MEQ + 1.08A + 0.55S)]
DMMFVM = 100 – DMMFFC
MMMFCV = [(CV – 50S)(100)]/[100 – (1.08A + 0.55S)]

Where:

DMMFFC = dry mineral matter free fixed carbon
DMMFVM = dry mineral matter free volatile matter
MMMFCV = moist mineral matter free calorific value, Btu/lb

FC = fixed carbon, moist basis
S = sulfur, moist basis
MEQ = equilibrium moisture
A = ash, moist basis
CV = calorific value, moist basis, Btu/lb

To convert Btu/lb values to kJ/kg, multiply the Btu/lb value by a conversion factor of 2.326.

Appendix 3

Conversion Chart

given base	required base	conversion
as received	dry	100/(100 – MAR)
as received	dry ash free	100/(100 – MAR – AAR)
as received	moist	(100 – MEQ)/(100 – MAR)
dry	as received	(100 – MAR)/100
dry	dry ash free	100/(100 – AD)
dry	moist	(100 – MEQ)/100

Where:

MAR = as received moisture
MEQ = equilibrium moisture
AAR = ash, as received basis
AD = ash, dry basis

Multiply the analysis component to be converted by the conversion factor in order to obtain the required base.

Appendix 4

Removed Overburden Data

The location given (meridian, township, range) represents the centre of a 9 township block. The removed overburden value represents the average removed overburden for the 9 township block.

Mer	Twp	Rge	Removed overburden (m)
4	5	5	886
4	11	5	995
4	14	14	1090
4	26	17	1363
4	29	17	1342
4	32	17	1236
4	35	17	1193
4	38	17	1167
4	41	17	1245
4	14	20	1588
4	17	20	1614
4	20	20	1659
4	23	20	1470
4	29	20	1344
4	32	20	1251
4	41	20	1242

Mer	Twp	Rge	Removed overburden (m)
4	44	20	1190
4	47	20	1249
4	50	20	1092
4	53	20	1284
4	8	23	1908
4	14	23	1678
4	50	23	1163
4	35	26	1550
4	38	26	1567
4	41	26	1658
4	44	26	1643
4	47	26	1638
4	53	26	1308
4	56	26	1197
5	44	2	1508
5	47	2	1527
5	50	8	1479
5	53	8	1557
5	56	8	1524
5	56	11	1414
5	59	11	1477